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A PROGRAM TO EVALUATE A VEHICLE TEST METHOD FOR PORT FUEL INJECTOR DEPOSIT-FORMING TENDENCIES OF UNLEADED BASE GASOLINES

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A PROGRAM TO EVALUATE A VEHICLE TEST METHOD FOR PORT FUEL INJECTOR DEPOSIT-FORMING TENDENCIES OF UNLEADED BASE GASOLINES

(CRC PROJECT No. CM-128-85)

Prepared by the

Fuel Injector Test Procedures Analysis Panel
of the
CRC Automotive Fuel Injector Deposit Group

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of the

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ABSTRACT

Car owners began complaining of operability problems with port fuel injector (PFI) systems late in 1984. Deposits within the tips of the pintle-type injectors of certain engines restricted fuel flow and caused misfiring. The automakers and gasoline marketers sought a test method that would enable determination of causative factors and consequent solutions. The Coordinating Research Council (CRC) Automotive Fuel Injector Deposit Group, organized in March 1986, developed a program which led to selection of a vehicle procedure for a round robin evaluation. The cycle involved 15 minutes operation at 88 kph (55 mph) followed by a 45 minute hot soak shutdown with total test durations of 4800 to 9600 km (3000 to 6000 miles). Twelve laboratories ran various combinations of three different base unleaded gasolines in five types of port fuel injected engines. From this set, data from 38 runs were analyzed, representing eleven laboratories and four engine types. Even though all test conditions were not tightly controlled, results showed statistically significant differences (at the 95% confidence level) in deposit-forming tendencies of the fuels as well as the vehicles. The test approach is useful for relative performance evaluations but more development effort is needed before it could serve as a quantitative measure.

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* Data presented in Appendices F and G are available on computer diskette in Lotus 1-2-3 Version 2.01 format. Contact the Coordinating Research Council, 219 Perimeter Center Parkway, Atlanta, Georgia, 30346.

I. INTRODUCTION

In the latter half of 1984 and progressing into 1985, there was an increasing number of car owner complaints of driveability problems with certain engines having port fuel injection systems. The injectors were of the same pintle design from a single source manufacturer.

Initially complaints developed in the Denver, Colorado area with some indication that certain unleaded gasolines were involved. With time, they spread to other geographical areas, particularly the southern states. Thus, a test method was needed to define the factors contributing to flow restricting deposits in the very close clearances between the injector pintle and body.

In October 1985, the Coordinating Research Council (CRC) held a forum in Tulsa, Oklahoma with open invitation to automaker, petroleum and supplier industry representatives to share information that might lead to defining a test. The CRC Automotive Fuel Injector Deposit Group was formally organized March 20, 1986, and divided into three subgroups. Two were assigned responsibilities for studying fuel composition and exploring possible laboratory bench tests to correlate with field performance. The third subgroup was charged with selecting a vehicle test procedure based upon field experience. This third group was called the Port Fuel Injector Test Procedure Subgroup.

Through individual member experience, a procedure was selected that could be applied to cars to generate injector deposits. There was sufficient indication that the procedure could be a useful tool to study factors affecting injector deposits, so a round robin program was conducted to explore repeatability and reproducibility. This report describes the program and results.

II. SUMMARY

Twelve laboratories participated as members of the CRC Automotive Fuel Injector Deposit Group in a round robin vehicle test program (Appendix A). The purpose was to evaluate a proposed technique for studying vehicle and fuel parameters leading to the formation of flow-restricting deposits within the critical metering area of pintle-type port fuel injectors (PFI). A copy of the test program is attached as Appendix B.

A prescribed test cycle was used by all participants. It consisted of a 15-minute running period at 88 kph (55 mph) followed by a 45-minute hot soak with the engine shut off. This was repeated for varying durations of typically 4000 to 9600 km (2500 to 6000 miles). Nominally, a test was ended when a set of fuel injectors suffered 20% or more average loss of flow due to deposits or when 9600 km was reached, whichever occurred first. Flow restriction was determined in a bench rig that accurately measured the quantity of fuel flowed through each injector when held open for precisely ten seconds. Flow measurements were made on injector sets initially and at 1600-km (1000-mile) intervals.

Based on field experience, three car makes were targeted for testing. However, participating laboratories also tested two other car makes. The test vehicles are described on Table I. All cars had automatic transmissions and the typical power accessories. Model years ranged from 1984 to 1986.

Three test fuels were provided from central sources so that each was common to all laboratories. The fuels were full boiling range unleaded base gasolines without any detergent, dispersant, or deposit control additives. The major compositional difference among them was in the olefin content, as shown below:

Fuel Code	% Total Olefins	Deposit Severity
CRC-9-86A	35	High
CRC-9-86B	5	Low
CRC-9-86C	12	Moderate

In total, the 12 laboratories tested 19 vehicles using the three fuels to yield 42 runs, including repeats. A summary of the runs is shown in Table III and also in Appendix C. In 38 of the 42 runs, the data were sufficiently complete to be included in the statistical analysis; data from the other four runs were omitted.*

Test results were expressed as percent flow restriction versus test duration in miles. For each injector set, data for the average injector and worst (most restricted) injector were

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* Laboratory 12 did not conduct flow tests at intermediate intervals. Consequently, data from this laboratory were excluded from the data set which was analyzed.

analyzed. The rate of flow restriction increase was analyzed statistically using a linear model and an exponential model. Both approaches yielded the same conclusions which follow:

- The 15/45 minute vehicle test cycle can significantly discriminate among base gasolines and among cars for injector deposit forming tendencies.

- Unleaded base gasolines exhibit significant differences in their tendencies to form port fuel injector deposits (95% confidence level).

- Car makes differ significantly in their tendencies to form port fuel injector deposits (95% confidence level).

- Different car makes appear consistent in their relative ranking of the deposit forming tendencies of different unleaded base gasolines.

- Simple linear modeling of injector set flow rates versus distance is a suitable basis for screening fuel and vehicle tendencies to form injector deposits with test durations of 4800 to 8000 km (3000 to 5000 miles).

- Exponential modeling of injector set flow rates versus distance may be more suitable for longer term tests.

- Fuel and vehicle effects on injector deposits may be represented similarly by both average injector set flow restriction and worst (most restricted) injector in the set. However, average set restriction is preferred to offset the greater uncertainty of a single measurement.

- Further procedure development is necessary to determine the potential for use as a quantitative industry method for port fuel injector cleanliness performance of gasolines.

There was evidence of good repeatability within various laboratories, even though it was not possible to control major test parameters closely as would be required for a uniform test. Compromises were made to make the program practical and timely. In spite of these compromises, the results support the usefulness of the technique in studying parameters affecting injector deposits. Further testing has been commissioned by CRC at an independent testing laboratory to provide vehicle validation data for studying laboratory bench tests as a more cost-effective approach to fuel and fuel additive evaluation.

III. TEST VEHICLES

The test program specified testing of three vehicle/engine configurations known to be subject to fuel injector deposit restriction in the field. As mentioned earlier, two other vehicle/engine configurations were also tested by two participating laboratories. Table I describes the vehicle/engine configurations tested.

Car Make D was chosen due to its identification with the earliest reports of the port fuel injector fouling complaints. Car Make G was chosen because of its high sales volume; also, this engine was thought to have mild deposit-forming tendencies. Car Make F was later involved in owner complaints in several geographical areas. Car Makes S and L, though not associated with customer complaints in the field, were tested by one laboratory each as independent choices.

All cars were tuned to meet manufacturer's specifications. To avoid variability due to engine break-in effects, testing was done only after more than 6400 km (4000 miles) had been accumulated. Since many of the laboratories had previously been testing for their own purposes, vehicles were readily available for this program. Also, it is believed that injector fouling is generally dependent on both engine design and underhood temperatures rather than engine/body combinations. Consequently, no test restrictions were made pertaining to body style, optional equipment, model design, etc.

The test results from Lab 12 (Runs 39 to 42) were excluded from the data analyses because they were incomplete. The laboratory submitted only beginning and ending injector flow data; data at intermediate intervals were not available.

IV. TEST FUELS

Three full-boiling unleaded base gasolines were tested. These are identified as CRC-9-86A, CRC-9-86B, and CRC-9-86C. Each laboratory was requested to make a repeat run on CRC-9-86A in one test vehicle of its choice. Testing of fuel CRC-9-86B was suggested but not required.

Based on earlier experience by individual laboratories, fuel CRC-9-86A was projected to form the most deposits, CRC-9-86C intermediate, and CRC-9-86B was projected to form the least. None of the fuels contained injector detergent, dispersant, or deposit control additives. A summary of typical inspections is shown in Table II. Complete inspection data are contained in Appendix D. Hereinafter, these fuels are referred to as "Fuel A", "Fuel B", and "Fuel C".

V. TEST PROCEDURE

The program outline, including testing technique, is presented in Appendix B.

The test vehicles operated on a uniform cycle of 15 minutes operation at 88 kph (55 mph) followed by a 45-minute engine-off soak. The procedure specified port fuel injectors be flow tested initially and at 1600-km (1000-mile) intervals thereafter. Nineteen vehicles of five engine types were operated either over the road, on outdoor mileage accumulation dynamometers, or on indoor chassis dynamometers. The specific operating conditions at each laboratory are described in Appendix E.

Each test vehicle was to run on two or more of the three test fuels. The program description in Appendix B mentions that Fuel A was projected to be more severe than Fuel C. Fuel B, which had not been defined at the start of the program, was intended to be of intermediate severity to Fuels A and C. After obtaining preliminary data on Fuel C, it was decided that Fuel B should be less severe than Fuel C to broaden the range of data.

All fuel injectors were of the pintle-type, according to the original engine manufacturer specifications. Injector flow measurements were taken at the start of each test and every 1600 km (1000 miles). Flow rates were measured as grams of flow medium (Stoddard solvent or iso-octane) through the injector which was kept energized for ten seconds. Rates were then expressed as grams per second. The complete set of injector flow data is shown in Appendix F.

Additional measurements included ambient air, inlet air, coolant, and fuel tank temperatures. Typical maximum/minimum temperatures were recorded for each 24-hour test period. Furthermore, one or more of the injectors in each engine set were equipped with thermocouples (located at the injector tip) to determine peak injector tip temperatures during the engine-off soak period. Complete temperature data are shown in Appendix G.

Average vehicle fuel consumption was also recorded. These data are presented in Appendix C.

Injector leak rates were measured according to the procedure described at the end of Appendix B. Injectors with leak rates greater than 2 mL air per minute were rejected.

The test fuels were analyzed by each participating laboratory at the beginning and end of the program. Fuel analyses included existent and unwashed gums (ASTM D 381-86), oxidation stability (ASTM D 525-86), distillation (ASTM D 86-82), and Reid vapor pressure (ASTM D 2551-80, ASTM D 323-82, or automatic method). These data are tabulated in Appendix D.

Required information included measurement of injector flow rates and, where possible, injector tip temperature. Test duration was targeted at 6400 to 9600 km (4000 to 6000 miles). Tests could be terminated early if one of the following conditions existed:

(1) 20% average injector plugging, or

(2) significant driveability disturbance.

VI. DISCUSSION OF RESULTS

Twelve participating laboratories submitted test data from nineteen vehicles but only results from eleven laboratories and seventeen vehicles were analyzed. The distribution of valid test data was as follows:

Car Make	Vehicle Engine Type	No. of Vehicles
D	2.2L, I-4, Turbo	8
S	2.8L, I-6	0
G	3.8L, V-6	3
F	5.0L, V-8	4
L	5.0L, V-8	2

Although testing of Car Make L was outside the original program, it was included as additional information. Data for Car Make S were incomplete and were not part of the data set analyzed.

As described earlier in the report, three unleaded base gasolines were tested:

Fuel	Deposit Forming Tendency
A	High
B	Low
C	Moderate

Insofar as possible, all laboratories were requested to run Fuel A and Fuel C. Fuel B was an option supplied later in the program.

A. Data Analysis Techniques

Table III shows the combinations of cars and fuels tested by each participating laboratory. All laboratories ran Fuel A, nine laboratories ran Fuel C, and only three laboratories ran Fuel B. A few laboratories also were able to run repeat tests for some car-fuel combinations.

Presentation of the results are in terms of percent injector flow reduction (average of all injectors in an engine relative to new, clean injector flow) versus test duration in miles. This is a direct indication of a vehicle's tendency to form injector deposits on a particular fuel. The "percent reduction relative to new injector flow rate" parameter was selected to put all vehicles on a common basis since new injector flow can vary from engine to engine. Injectors which stayed clean would show no reduction in percent of new injector average flow rate. A high deposit forming fuel would show a rapid increase in percent reduction of flow rate after a relatively short duration (few test miles).

Prior experience by several participants with the 15/45 minute test cycle had shown that the injector flow rate change with test duration was essentially linear over 4800 to 8000 km (3000 to 5000 miles). Thus, each test could be fairly represented by a least squares straight line through the flow rate reduction measurements versus test duration. A more advanced method of data analysis, which will be discussed later, took into account possible curvature of the flow rate reduction response. However, both the simple and the more complex methods yielded the same conclusions. Detailed discussions of both methods of analysis are contained in Appendix H.

In addition, the data were analyzed using the worst (most restricted) injector in a set rather than the average level of injector restriction. Again, the same conclusions were reached.

B. Multiple Linear Regression Analysis

Results of the program are shown in a series of graphs of average percent flow reduction (relative to new injector flow) versus test duration. Each test curve (or least squares straight line) can be characterized by its slope. This yields a single value that can be treated by multiple regression analysis to determine car effects, fuel effects, and possible interactions.

On this basis, the round robin program showed:

a) The three fuels are significantly different from each other (95% confidence level):

Fuel A - High Deposit Forming

Fuel C - Moderate Deposit Forming

Fuel B - Low Deposit Forming

b) The four vehicle/engine configurations could be divided into three groups which are significantly different from each other (95% confidence level):

Car F (5.0L V-8)	- High Severity
Car D (2.2L I-4 Turbo)	- Moderate Severity
Car G (3.8L V-6)	- Moderate Severity
Car L (5.0L V-8)	- Low Severity

Additionally, the analysis showed the interaction of cars and fuels to be significant at the 95% confidence level. Therefore, the data are discussed for the three fuels in each of the car makes.

The most concise presentation of the overall results of the round robin program is given in Figure 1, which shows the percent flow reduction (relative to new injectors) versus test duration for the average of each fuel in each of the four car makes.* Fuel A is clearly the highest deposit-forming fuel in all cars. Responses in Car D and Car G are similar, whereas Car F forms deposits at about twice the rate of the other two and Car L forms deposits at about 1/4 the rate of the other two.

* Car Make L was only tested with Fuel A.

A similar picture is evident for Fuel C, which exhibits an intermediate deposit-forming tendency. Comparatively, Fuel B shows little deposit-forming tendency in all three cars. In 4800 km (3000 miles), only 3% or less average flow reduction occurred with Fuel B. The original program instructions were to extend any test run to an average flow reduction of 20% or to a test duration of 9600 km (6000 miles). Thus, all laboratories testing Fuel B ran the full test duration, at which point one laboratory reached 4.4% average flow reduction and the other two reached 2.3% and 2.0%.

On the basis of the above test results, it may be concluded that the 15/45 minute vehicle test procedure does significantly discriminate between base gasolines of different deposit-forming tendencies. As a corollary conclusion, unleaded base gasolines can differ significantly in their deposit forming tendencies. A further conclusion relative to car makes is that vehicle/engine configurations can differ significantly in severity or tendency to form deposits which restrict injector flow. It is also noteworthy that the distinctly different car makes ranked the test fuels in the same relative order of deposit forming tendencies. Hence, there appears to be a consistency among makes that are subject to field complaints.

As amplification of the car make severity question, recall that a fourth vehicle/engine combination, Car Make L, was tested outside the original program design but with the same test procedure and the same Fuel A. Although the engines in Car Makes F and L were both 5.0L V-8, they differed significantly in their sensitivity to deposit formation, as shown in Figure 2.

C. Multiple Linear Regression of Exponentially Transformed Data

About one-third of the test runs in the program showed evidence of some curvature. Without regard to car make or fuel type, those particular curves are plotted together in Figure 3. The extent of curvature appears to be greater with extended test duration. In addition, as one might expect, test variability increased with test duration (i.e. standard deviation was a function of test duration). Therefore, the data were subjected to more sophisticated exponential modeling suitable for this type of data versus the previous simple linear model.

First, the data were transformed exponentially, which linearized the data and "normalized" the standard deviations. Then, the transformed data were subjected to multiple linear regression. From the resulting least-squares best-fit model, parameter estimates were generated at 4800, 9600, and 16,000 km (3000, 6000, and 10,000 miles).* The parameter values at 4800 km (3000 miles) are listed in Table IV. The estimated flow reductions were calculated by using the equation shown at the bottom of the table using appropriate values for a fuel parameter (f), a car parameter (c), and the intercept (I). For example, the estimate of the flow reduction for Car D on Fuel A at 4800 km (3000 miles) was determined as follows:

$$\%\ \text{Flow Reduction} = \frac{100}{1 + \exp[-(-4.046+0.774+1.292)]} = 12.1\%$$

The other values shown on the table were calculated in a similar manner.

Conclusions from this analysis of exponentially transformed data coincide with those from the simple linear analysis. The differences among Fuels A, B, and C and among Cars F, D & G, and L were significant at the 95% confidence level.

A more thorough discussion of this method and tabulations of the parameter values at other test length intervals is contained in Appendix H.

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* The latter interval is a considerable extrapolation from the maximum actual test duration of 9600 km (6000 miles).

D. Data Variability

This round robin program was intended to give a general assessment of the feasibility of the 15/45 minute test cycle as a means for evaluating fuel deposition tendencies. A reasonable effort was made to control the major parameters believed to affect injector deposits, i.e. vehicle/engine configuration, fuel, and driving pattern. Other parameters, such as injector tip temperatures, coolant temperature, and ambient temperatures, were measured to help explain spurious results.

To minimize vehicle/engine effects, it was the intent to test only three vehicle/engine configurations (D, G, and F), but each laboratory could use the model year car already on hand. This resulted in a variation of up to three model years. However, all laboratories had to use the same batches of fuel and a common engine oil. No cars were exchanged among laboratories, so car and laboratory effects were confounded. Also each laboratory was free to run cars anytime during the year, and test operation could be either on the road or on a chassis dynamometer.

In spite of the freedom of approach in testing, the results proved the basic test approach is useful for fuel and/or car testing. However, the variability encountered limits the applicability of the round robin procedure as a method for quantifying injector fouling. A significant development program would be required to refine testing technique.

To illustrate the variability factors, the linear least squares regression lines are shown in Figures 4, 5, and 6.

Figure 4 shows results for all laboratories using Car D with each fuel. There is clearly much higher variability with Fuel A, the one most prone to form deposits. Reproducibility between car/laboratory combinations is poor, ranging up to 30 percentage points at 4000 km (2500 miles). For the three laboratories that made repeat runs (Labs 1, 8, and 11), the variability is somewhat lower. Tests within Lab 8 (Runs 27 and 28) were fairly close together, suggesting the possibility of more precise testing with some development effort. One possible reason for the high variability of results for Fuel A was the stability of the fuel. This issue will be discussed later in this report.

A similar presentation of results for Car G is shown in Figure 5. Here the number of runs is more limited. Note that the runs for Lab 2 with Fuel A (Runs 7 and 8) show relatively poor repeatability, while those for Lab 3 (Runs 10 and 11) are very good.

One of the reasons for differences between Runs 7 and 8 is that Lab 2 modified the car after Run 7. The laboratory observed that maximum injector tip temperatures in Run 7 were lower than expected. Consequently, for Run 8 the laboratory added a hood shield to elevate maximum injector tip temperature. In retrospect, it may have been technically justifiable to exclude Run 8 from the data set, but the differences between the two runs were within the test precision observed in this program. Consequently, Run 8 was retained in the data set.

Figure 6 presents results for Cars F and L. Car F is clearly the most severe vehicle/engine configuration. Repeatability within Labs 7 and 9 for Car F with Fuel A was excellent. With Fuel C, repeatability was somewhat poorer, and Run 30 appears to be excessively severe relative to the rest of the tests with this fuel. The two tests by Lab 4 with Fuel A in Car L (Runs 14 and 15) repeated very well, especially considering that the tests were conducted in two different cars. Again, these results suggest that test variability may be controlled to yield a useful quantitative performance test method.

E. Average Versus Worst Injector Concepts

A characteristic observation of deposit formation in injector tips is that a set of injectors in an engine do not become uniformly restricted during a given vehicle test. There is usually a large spread between the cleanest and the most restricted injector.

Thus, there is a question of how best to represent quantitatively the performance of a fuel in an engine. Since there is a high variability in the behavior of individual injectors, it was considered that averaging the flow restriction for a complete set of injectors would tend to average out some of the variability and give a better estimate. In support of this concept, the raw test data were compared on the basis of the injector set averages versus the worst single injector in each set.

Figures 7, 8, and 9 provide a visual comparison for all of the program data. The data are separated by fuels and car makes. Figures 7A and 7B show the data for Fuel A in terms of the average and the worst injector, respectively. Similarly, Figures 9A and 9B show the data for Fuel C. In Figure 8, the comparable data for Fuel B are condensed into two plots because few data points were available. Note that the scale of the y-axis for the plots of average injector flow reduction differs from those for worst injector flow reduction.

A visual comparison of the plots of average versus worst injector results reveals a strikingly similar appearance. This is true for each fuel in each car. Consequently, the same general conclusions regarding the overall fuel and car effects can be drawn whether they are based on injector set averages or on the worst single injector in a set.

F. Fuel Stability

One of the possible causes of poor test precision was poor fuel stability. This issue was of great concern to the program panel because of the possible correlation between poor stability and high deposit formation and because of the extended time frame over which the tests would be conducted.

To determine whether fuel stability had changed during the program, inspections were conducted on each of the test fuels by each of the participating laboratories, both before and after the vehicle tests. These inspections included tests for unwashed and washed gums, induction period, Reid vapor pressure, and distillation. Appendix D contains a complete tabulation of the inspection results. An indication of the time frame over which these inspections were obtained is given in Figure 10.

For evaluating the significance of the results, reliance has been placed on the less stringent reproducibility criteria from the ASTM standards, rather than the repeatability standards, since the intra-laboratory measurements were made several months apart.

Fuel A - The ASTM D 381 gum results from Lab 5 differ significantly from those of the other laboratories, both before and after the vehicle test program. These results were probably due to differences in calibration or technique rather than real differences in fuel characteristics, because Lab 5 obtained vehicle test results which were similar to results obtained at other laboratories.

Labs 2 and 7 measured an increase in existent gum levels from the beginning to the end of the test. While these results are statistically significant and while they suggest that the fuel was changing, the changes could not be correlated with changes in the deposit-forming characteristics of the test fuel.

Labs 5, 9, and 11 measured a significant reduction in induction period over the course of the test program. These reductions may be due to storage conditions at these laboratories.

Lab 4 measured lower than average Reid vapor pressure (RVP) and greater than average reduction in RVP. These differences were probably due to storage practices or sampling techniques. The laboratory stored its fuel in an above-ground tank during the summer in the southern part of the country. Among the other laboratories, differences in RVP of minor significance were observed, both between laboratories and between initial and final inspections at individual laboratories.

Some minor differences in ASTM D 86 distillation characteristics were observed, particularly with respect to Lab 4. These differences were not of sufficient magnitude to cause concern.

__Fuel B__ - The inspection data for this fuel were very limited; however, they did not indicate any significant change in the fuel over the course of the test program.

__Fuel C__ - The variation in the inspection data for this fuel is much less than that for Fuel A. Perhaps the fuel was less sensitive to storage and handling practices because it had a lower volatility and it contained oxidation inhibitors.

With the exceptions noted above, the analysis of the fuel inspection data indicates that overall there were only minor differences in fuel characteristics, both among laboratories and between initial and final inspections by individual laboratories. These differences do not reveal contamination nor significant deterioration of the fuels during the program. It should be noted, however, that these inspections address only the macroscopic characteristics of the fuels. Changes in more subtle fuel characteristics which might be related to deposit-forming tendencies cannot be ruled out.

G. Injector Tip Temperatures

As mentioned earlier, part of the program included monitoring of ambient temperatures and injector tip temperatures, plus the option of monitoring a few other key temperatures. A tabulation of the data collected is given in Appendix G.

While much data were collected, the manner in which they were obtained was not sufficiently controlled to provide consistent data logging. A cursory analysis of the data did not reveal a strong relationship between the temperature data and deposit formation. Because of the inconsistencies, a thorough analysis of the temperature data was not possible.

H. Program Timing

While it was desirable for participants to run this program all in the same time frame, it was not possible due to other priorities within the various laboratories. Figure 10 shows the program duration for each participating laboratory. Some began the program early and finished in a short time (2 months), while others extended the program over 7 to 8 months.

Most participants ran 24 hours per day continuously while others had protracted shutdowns (weekends, evenings, etc.) No correlation could be made between length of test time in relation to injector deposit formation rates.

ACKNOWLEDGEMENT

The CRC PFI Round Robin Analysis Panel gratefully acknowledges the contributions of Mr. Louis J. Painter, a statistics consultant, who provided the statistical analyses of the data from this program.

TABLES AND FIGURES

TABLE I

TEST CAR ENGINE CONFIGURATIONS

Car Make	Displacement (L)	Number of Cylinders	Turbocharged
D	2.2	4	Yes
S *	2.8	6	No
G	3.8	6	No
F	5.0	8	No
L **	5.0	8	No

* Car Make S was not specified for the round robin program. However, it was tested by one laboratory, Lab 12. As mentioned in the report, data from Lab 12 were not included in the data analysis because the data were incomplete.

** Car Make L was not specified for the round robin program. However, it was tested by one laboratory, Lab 4, using the program procedure on one CRC fuel. Since the data reported were complete, they have been included in the analysis as supplemental information.

TABLE II

TYPICAL TEST FUEL INSPECTIONS

	FUEL A CRC-9-86A	FUEL B CRC-9-86B	FUEL C CRC-9-86C
Gravity, °API	59.9	62.3	54.8
Specific Gravity @ 15.6 °C	0.74	0.73	0.76
Distillation, °C			
Initial	33	38	37
10% Evaporated	48	58	55
50% Evaporated	106	108	108
90% Evaporated	188	172	171
End Point	218	204	223
Total Olefins, % Vol.	35	5	12
Induction Period, minutes	270	360+	360+
Reid Vapor Pressure, kPa	81	61	52
(psi)	(11.8)	(8.9)	(7.5)
Gum, mg/100 mL			
Unwashed	7.0	2.6	2.0
Washed (Existent)	6.0	0.4	0.6
Sulfur, % Wt	0.08	0.01	0.03

TABLE III

VEHICLE AND FUEL COMBINATIONS TESTED BY PARTICIPATING LABORATORIES

Lab	Fuel	Vehicle Make and Engine Type (Number in parentheses identifies Run Number)					Number of Runs per Test Fuel		
		D 2.2L I-4 Turbo	S 2.8L I-6	G 3.8L V-6	F 5.0L V-8	L 5.0L V-8	A	B	C
1	A	(1) (2) (3)					3		
	B								
	C	(4)							1
2	A	(5)		(7) (8)			3		
	B								
	C	(6)		(9)					2
3	A			(10) (11)			2		
	B			(13)				1	
	C			(12)					1
4	A					(14) (15)	2		
	B								
	C								
5	A			(16)			1		
	B								
	C			(17)					1
6	A	(18)					1		
	B	(19)						1	
	C								
7	A				(20) (23) (24)		3		
	B				(26)			1	
	C				(21) (22) (25)				3
8	A	(27) (28)					2		
	B								
	C								
9	A				(29) (31)		2		
	B								
	C				(30) (32)				2
10	A	(33)					1		
	B								
	C	(34)							1
11	A	(35) (36) (37)					3		
	B								
	C	(38)							1
12	A	(39)*	(40)*				2		
	B								
	C	(41)*	(42)*						2
Total Runs per Fuel							25	3	14
Total Runs per Car Make		18	2	9	11	2	= 42 Grand Total		
Runs Analyzed							38		

* Excluded from analysis because data incomplete.

TABLE IV

ANALYSIS OF EXPONENTIALLY-TRANSFORMED DATA

ESTIMATED FLOW REDUCTION @ 4800 KM (3000 MILES)
(Based on Least Square Means)

Intercept		Fuel A	Fuel B	Fuel C	Average Fuel
I =	-4.046	0.774	-1.301	0.000	-0.176 ← (f) Fitted Effects
		% Flow Reduction @ 4800 km *			
Car D	1.292	12.1	1.7	6.0	5.1
Car G	1.003	9.4	1.3	4.6	3.8
Car F	2.064	23.0	3.6	12.1	10.4
Car L	0.000	3.7	0.5	1.7	1.4
Average Car	1.090	10.1	1.4	4.9	4.2

↑ (c) Fitted Effects

$$* \quad \% \text{ Flow Reduction} = \frac{100}{1 + \exp(-(I+f+c))}$$

Figure 1

PFI ROUND ROBIN SUMMARY
LEAST SQUARES REGRESSION

Injector Set Average

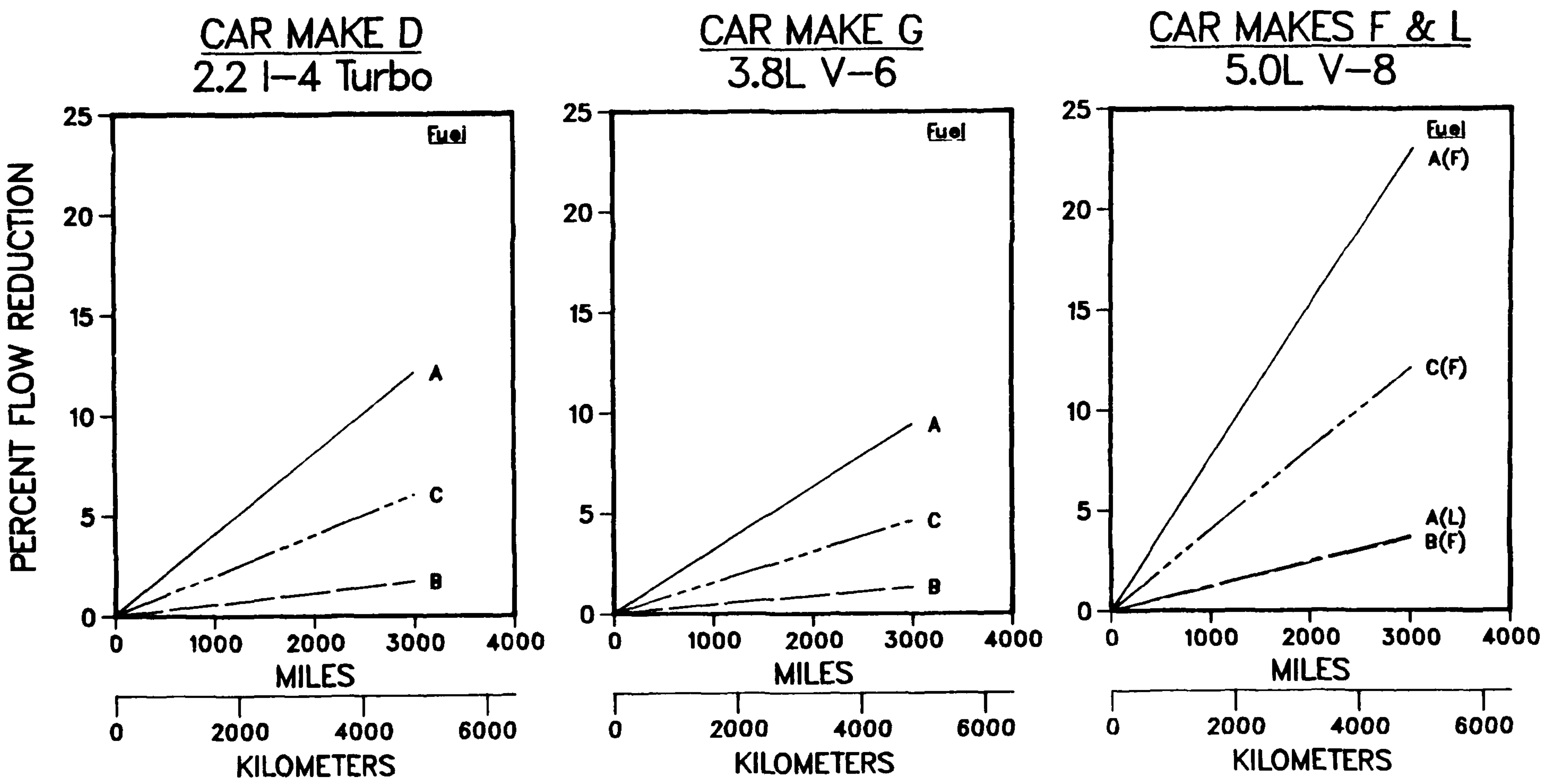


Figure 2

COMPARISON OF CAR SEVERITY
<u>OF DIFFERENT MAKES</u>
5.0L V–8

FUEL A

INJECTOR SET AVERAGE

WORST INJECTOR

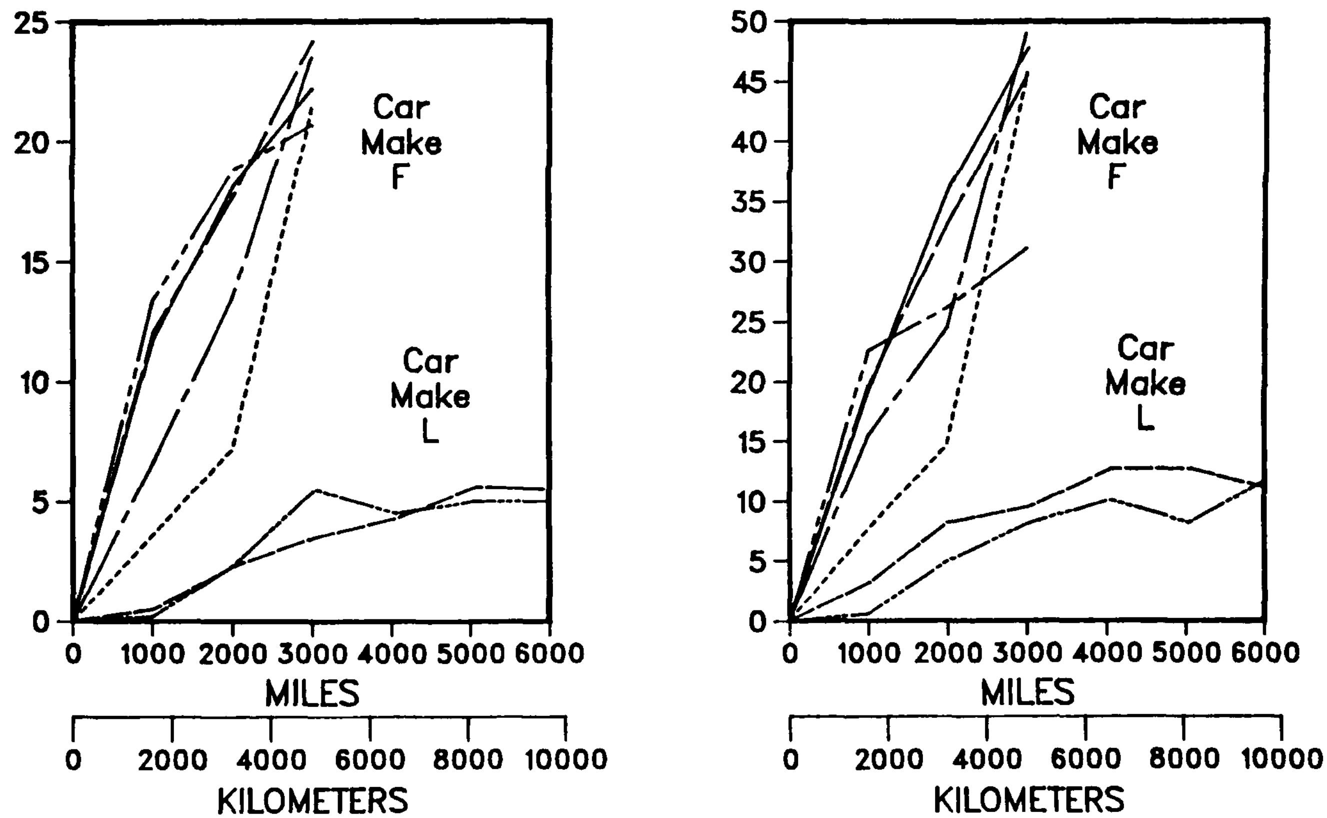


Figure 3

TEST RUNS SHOWING NON–LINEAR CHARACTERISTICS
IN RATE OF FLOW REDUCTION
Various Fuels & Car Makes
Injector Set Averages

CODE: Lab,Car(Run)

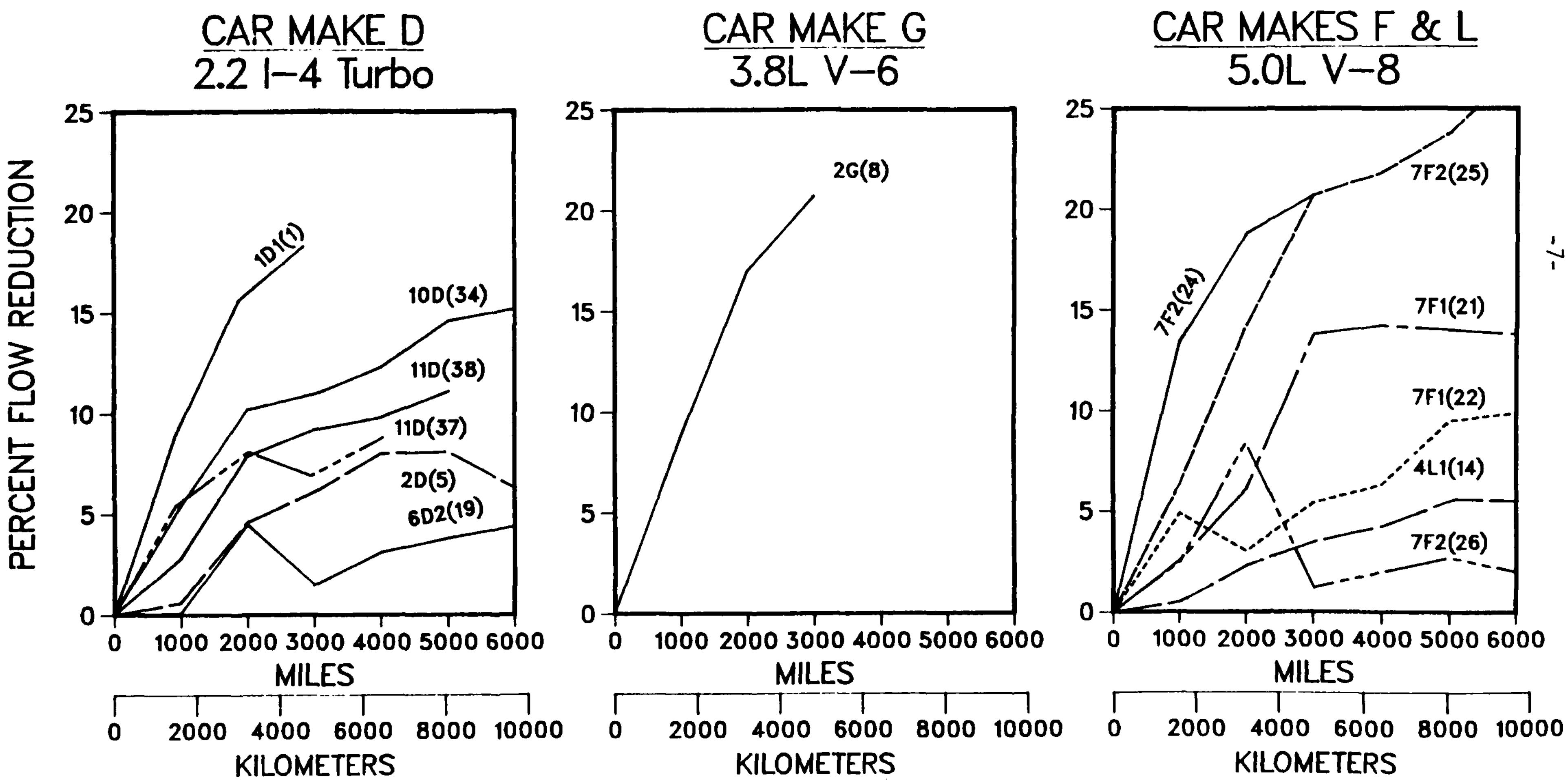


Figure 4

DATA SUMMARY
BASED ON
LEAST SQUARES REGRESSION

CODE: Lab,Car(Run)

CAR MAKE D: 2.2L I–4 Turbo
Injector Set Average

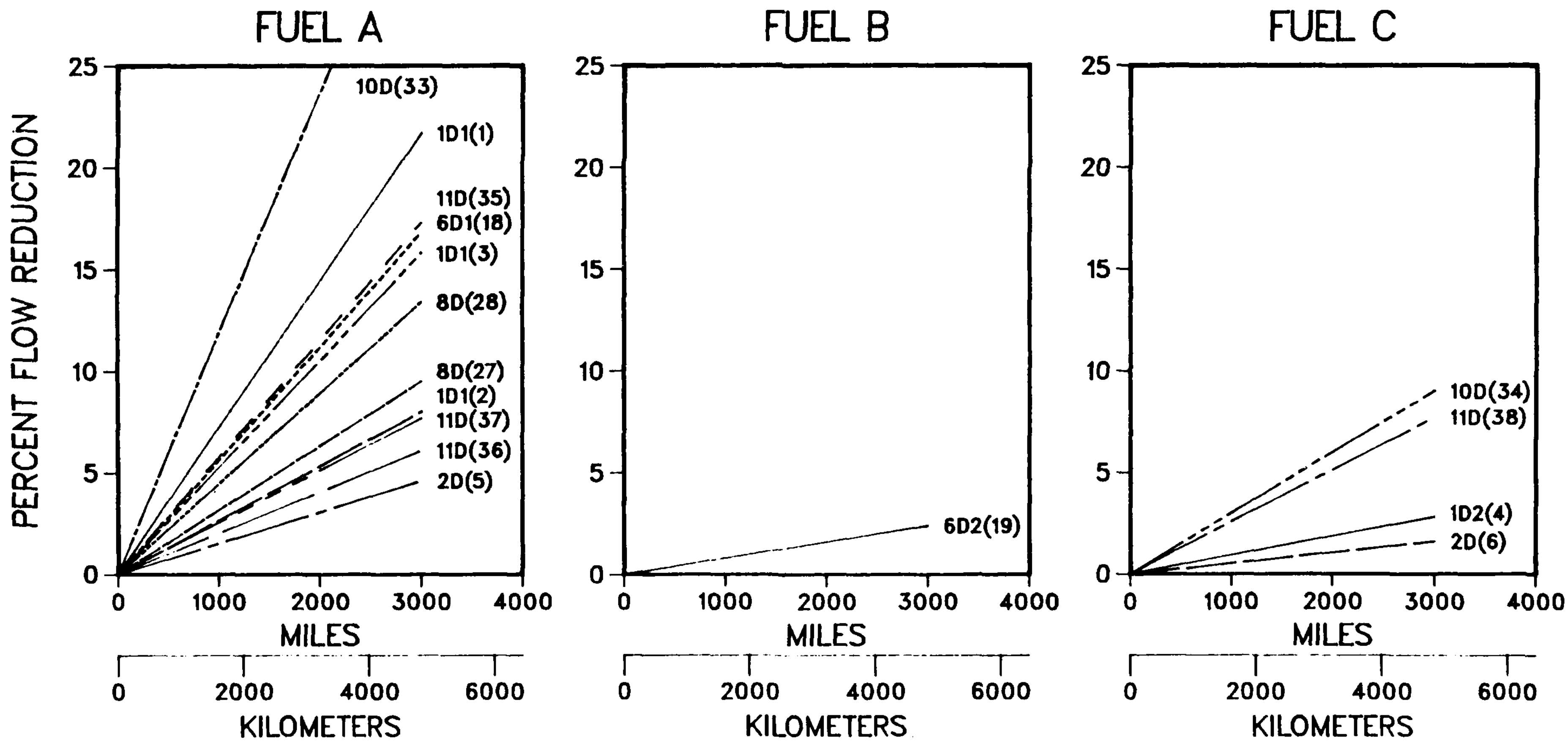


Figure 5
DATA SUMMARY
BASED ON
LEAST SQUARES REGRESSION

CODE: Lab,Car(Run)

CAR MAKE G: 3.8L V–6
Injector Set Average

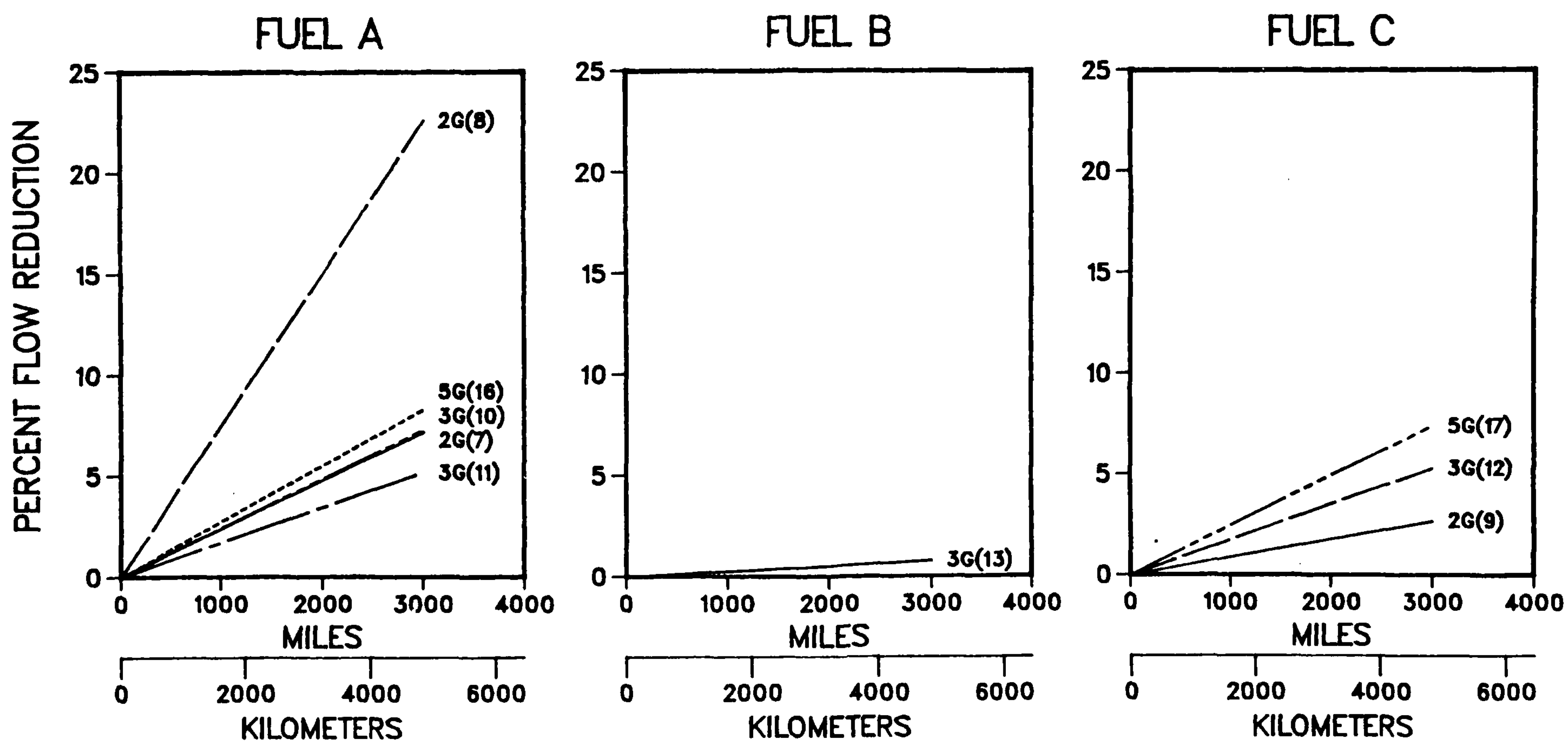


Figure 6
DATA SUMMARY
BASED ON
LEAST SQUARES REGRESSION

CODE: Lab,Car(Run)

CAR MAKES F & L: 5.0L V–8
Injector Set Average

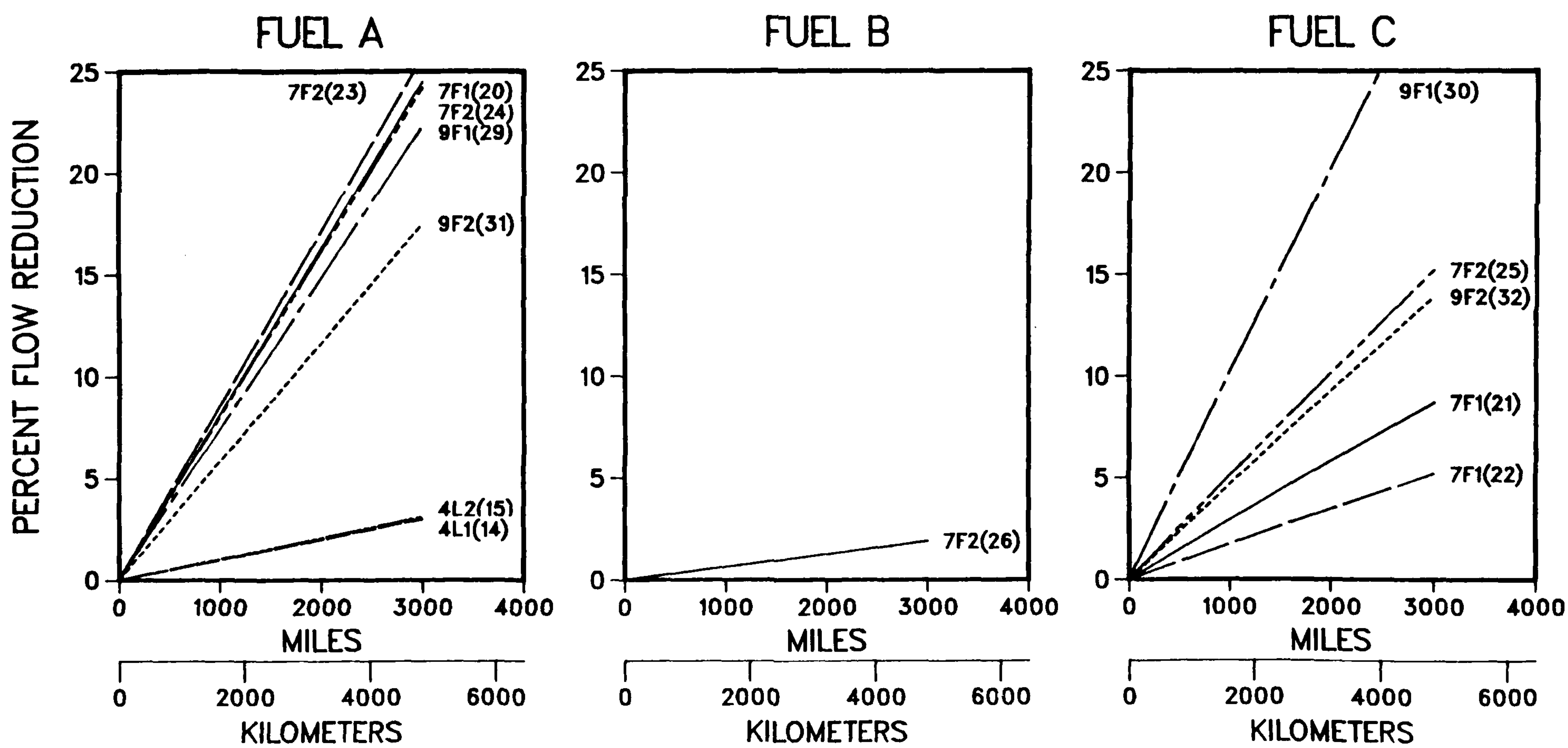


Figure 7A

FUEL A

Injector Set Average

CODE: Lab,Car(Run)

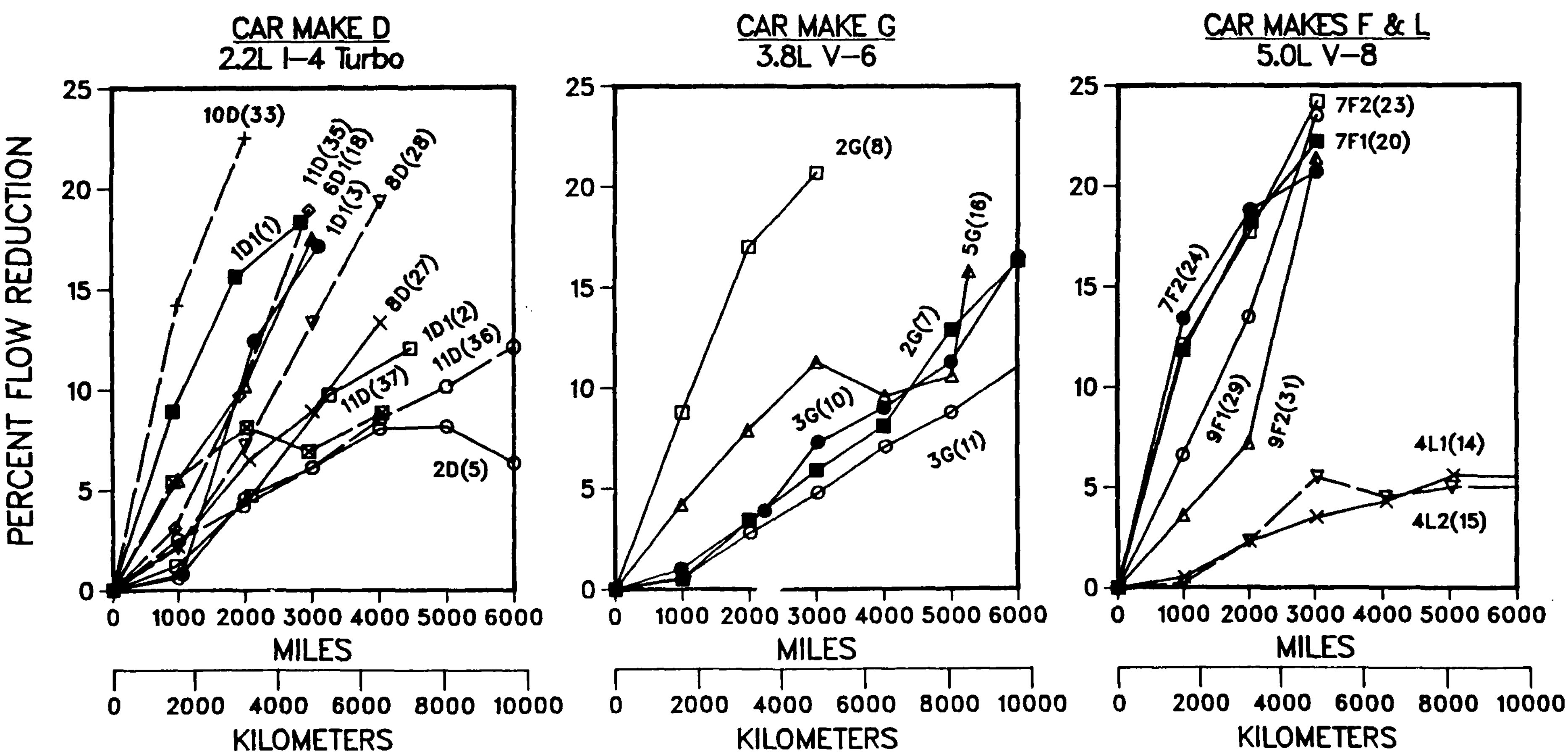


Figure 7B
FUEL A
Worst Injector

CODE: Lab,Car(Run)

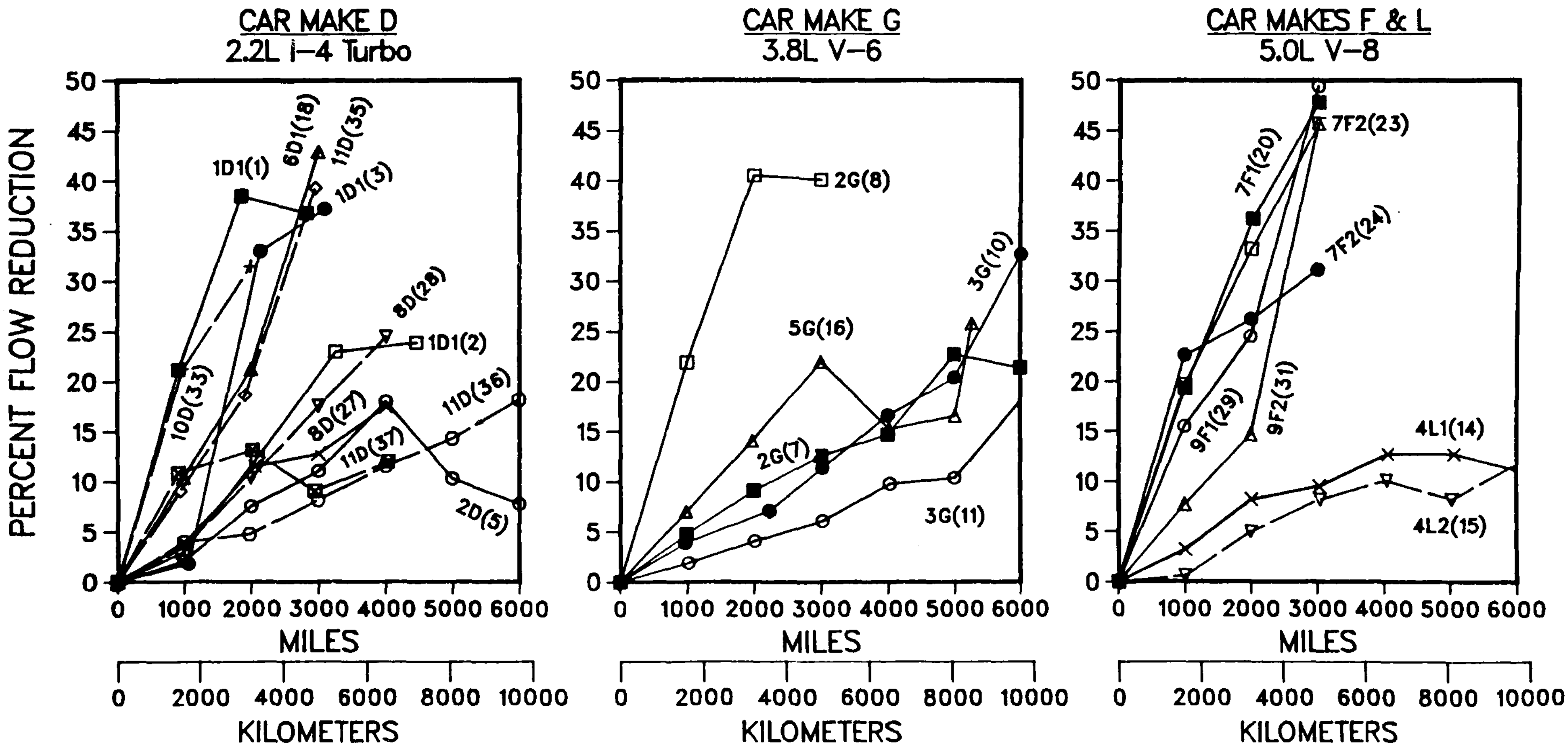


Figure 8

FUEL B

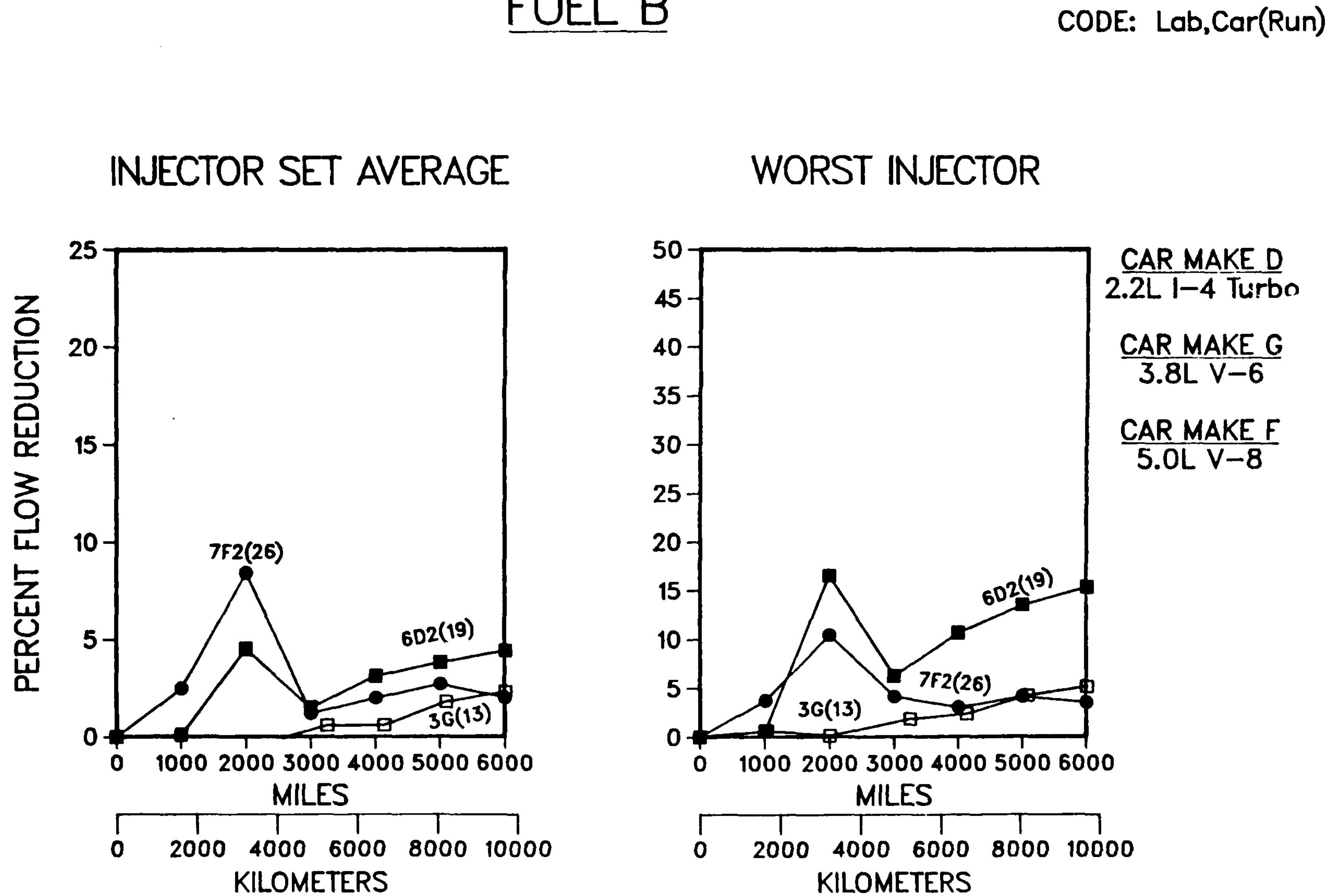


Figure 9A

FUEL C
Injector Set Average

CODE: Lab,Car(Run)

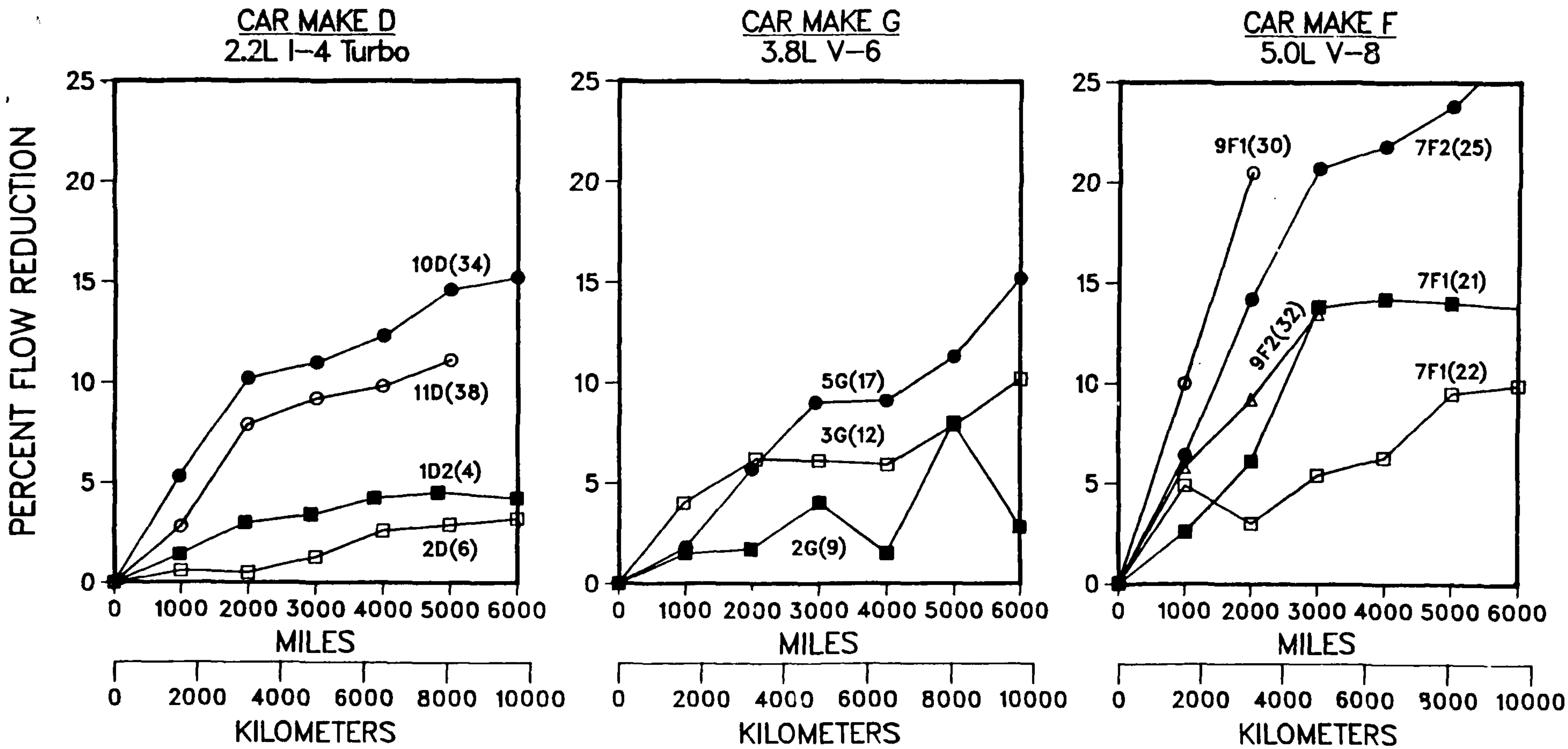


Figure 9B

FUEL C

Worst Injector

CODE: Lab,Car(Run)

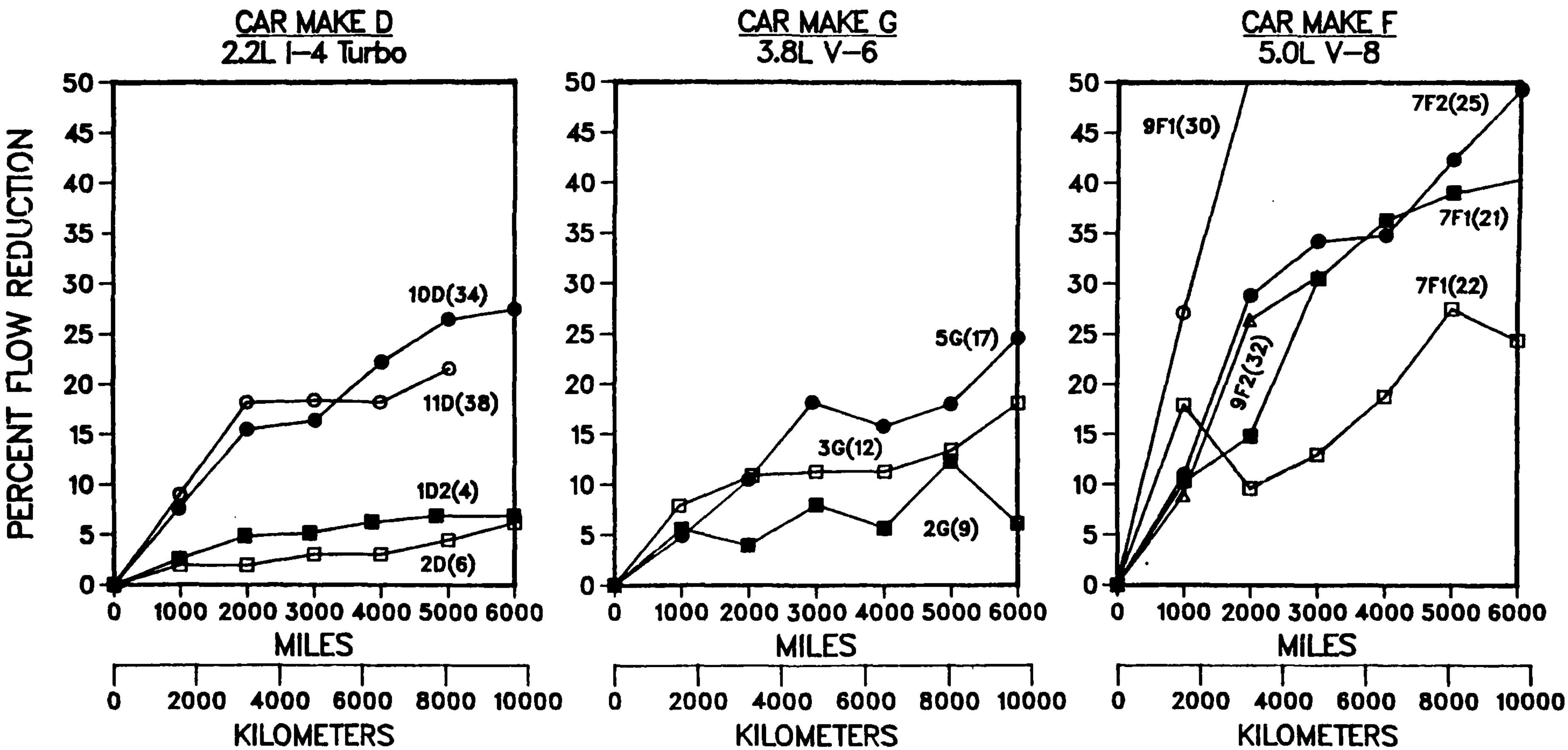
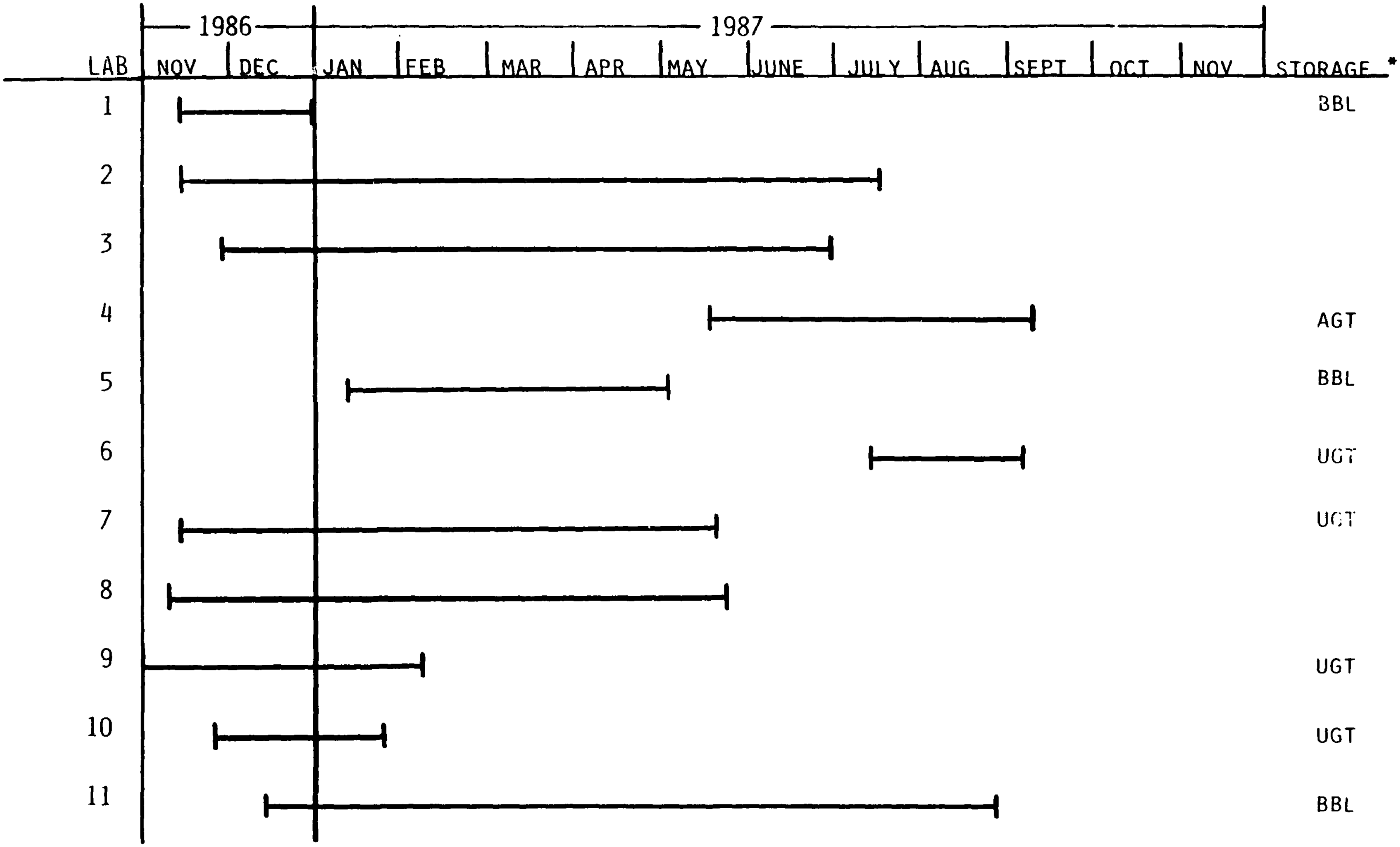


FIGURE 10

PROGRAM TIMING



* FUEL SUPPLY SYSTEM

BBL = 55 GALLON DRUM

AGT = ABOVE GROUND TANK

UGT = UNDER GROUND TANK

APPENDIX A

CRC PFI ROUND ROBIN PROGRAM PARTICIPANTS

Amoco Oil Company

Ashland Petroleum Company

Chevron Research Company

E. I. DuPont de Nemours & Co., Inc.

Exxon Research and Engineering Company

General Motors Research Laboratories

The Lubrizol Corporation

Mobil Research and Development Corporation

Nalco Chemical Company

Shell Development Company

Standard Oil Company

Unocal Corporation

CRC PFI ROUND ROBIN ANALYSIS PANEL MEMBERS

R. C. Tupa (Leader) L. Jokubaitis	-	The Lubrizol Corporation
G. Abramo	-	Mobil Research and Development Corp.
L. Beard	-	Amoco Oil Company
J. D. Benson	-	General Motors Research Laboratories
B. Y. Taniguchi	-	Chevron Research Company
T. Wusz	-	Unocal Corporation

APPENDIX B

TEST PROGRAM PLAN FOR CRC PORT FUEL INJECTOR DEPOSIT EVALUATION IN VEHICLES

AND

INJECTOR LEAK RATE TEST PROCEDURE

CRC ROUND ROBIN PFI PROGRAM

Project No. CM-128-85

TABLE OF CONTENTS

CRC ROUND ROBIN PFI PROGRAM

PURPOSE

The purpose of this program is to evaluate the port fuel injector deposit forming characteristics of test gasolines as a basis for correlation with fuel properties and simple bench screening tests.

Results are necessary to achieve the objectives of the CRC Fuels Task Force and the CRC Bench Test Task Force. The Program will provide a measure of test reproducibility among laboratories and provide the basis for development of a standard CRC test procedure to qualify future test fuels.

PROGRAM TIMING

The sooner the results of this program can be achieved, the greater their value. Questions of work priorities within the participating labs must be recognized. Nevertheless, the following timing targets are suggested as desirable:

1.	Test fuels available to participants	September 15, 1986
2.	Start of testing	October 1, 1986
3.	End of testing	Jan. 2, 1987

PROGRAM OUTLINE

A common test procedure will be used to evaluate the deposit forming tendencies of two fuels in each of two port fuel injected cars. Beneficial to the program is a repeat run on one fuel in one car of each laboratory's choice. Any additional repeat runs, though optional, would be very valuable. A third fuel may be offered at a later date.

Required information is measurement of injector flow rates and, where possible, injector tip temperatures. Test duration is 4000 miles (minimum) to 6000 miles (maximum). Other criteria that may be used to determine end of test: 1) 20% avg. plugging or 2) significant driveability disturbance.

Chemical and physical data on the three test fuels will be provided.

TEST PROGRAM

Test Cycle

To minimize variability, all labs are requested to run the following operating conditions:

- 15 minutes at 55 mph (road load); specifics of operation should be the same as previously reported by the labs.
- 45 minutes hot soak - engine shut off.

Vehicle running conditions may be accomplished on a test track, road simulator or chassis dynamometer. It is important that the test vehicles be rapidly brought to 55 mph, as well as back to zero at the end. For open road operations, it is desirable to minimize the travel distance to reach the operating speed of 55 mph. --

For hot soak, no special options are needed, (e.g., blankets, engine shrouds, etc). (The intent is to run vehicles in a realistic way " simulating" customer experience.) Continue hot soaks indoors or outdoors, whatever the previous practice has been at each participating laboratory.

ALL TESTS, INCLUDING REPEAT RUNS, ARE TO START WITH NEW, FLOW-RATED INJECTORS.

Test Fuels

Two full boiling, commercial type unleaded base gasolines (identified as CRC-9-86A and CRC-9-86C) are to be tested in the order given. Each laboratory is requested to make a repeat run on CRC-9-86A in one test vehicle as chosen by each laboratory.

Based on limited vehicle testing, the above fuels have been selected to give high and low injector deposit forming tendencies. Fuel CRC-9-86A is projected to form the most deposits and CRC-9-86C the least.

A third fuel of intermediate deposit forming tendency was originally intended to be included. Variability of the third fuel created uncertainty about its selection. This is being further investigated with the intent of making such a fuel available in the near term. Until then, the program will be based on the high and low deposit fuels.

None of the fuels contain detergent/dispersant additives. Typical properties and analyses for each fuel will be provided to all participants when the fuel batches are made available. Ordering instructions are as follows:

Reference Fuel CRC-9-86A (High Deposit)

Contact: Ashland Petroleum Co.
Attn: L. M. Ferguson
APAL, P.O. Box 391
Ashland, Kentucky 41114

Phone: (606)329-5297

When ordering, refer to "Ashland PFI Reference Fuel, Batch Four" in all correspondence. Price is $2.50 per gallon bulk, F.O.B. Ashland Terminal at Ironton, Ohio. Requests for drum quantities are discouraged, but can be made available at $3.00 per gallon.

Reference Fuel CRC-9-85C (Low Deposit)

Contact: Phillips 66 Company
Attn: Linda Remke
6 B2 Adams Building
Bartlesville, Oklahoma 74004

Phone: (918)661-4479

This fuel is from Phillips Batch No. 26. Price at August 22, 1986 was $1.82 per gallon in tank cars and tank trucks. The price for 55 gallon drums as of August 22 was $2.43 per gallon, F.O.B. Sweeny, Texas. This fuel is also known, generically, as "Phillips J".

NOTE:
It is recommended that storage of fuels in 55 gallon drums be in a protected area to shield them from rain or other possible water contamination. Whenever possible, inside storage is preferred.

Engine Oil

The same engine oil should be used throughout the program. A single source supply has been arranged so that all participants can use the identical oil which is an SAE 10W-30 viscosity grade of API SE quality.

It was formulated as a standard reference and should be ordered from:

ASTM Test Monitoring Center
4400 Fifth Avenue
Pittsburgh, PA 15213
Attn: Paul R. Eisamann

Phone: (412)268-3314

The oil is referred to as "Oil 200" and is priced at $35.00 per gallon, F.O.B. Pittsburgh. It will be billed and shipped freight collect against a purchase order from each participating company. When ordering, refer to:

CRC PFI Round Robin Program

For any participant company that is doing motor oil sequence testing, existing purchase order numbers may be used.

Fuel Injectors

OEM part number injectors ONLY are to be used as manufactured by Bosch.

MEASUREMENTS

Vehicle Performance

All test cars should be tuned and perform according to manufacturer's specifications. To avoid any variability due to engine break-in-effects, testing should begin only after 4000 or more odometer miles have been accumulated.

Test Fuels

Two full boiling, commercial type unleaded base gasolines are to be tested. Based on limited vehicle testing, they have been selected to give high and low injector deposit forming tendencies. Fuel A is projected to form the most deposits and Fuel C the least.

THE ORDER OF FUEL TESTING WILL BE: FUEL A FOLLOWED BY FUEL C.

The fuels do not contain detergent/dispersant additives. Typical properties and analyses are given for each fuel in the Appendix.

As a check on fuel uniformity, each lab is asked to run the following tests for each fuel upon shipment arrival and at the end of the test program:

- D381 (gum)
- D525 (stability)
- R.V.P.
- ASTM distillation

Engine Oil

The same crank case engine oil should be used throughout the program by all labs. Each test run should be flushed with fresh oil following an oil filter change. Drain the oil, change filter, and put in a fresh change of the same oil for the test.

Because of the limited mileage of each test, it is not considered necessary to save or analyze drain samples. Any such measurements are at the discretion of each participant.

Fuel Rail Pressure

The injector fuel rail pressure in the vehicle must be at manufacturer's specified level. A malfunctioning pressure regulator will cause decreasing rail pressure which can cause a decrease in deposit formation. Check this pressure at least once each day.

Injector Flow Ratings

1. The laboratory flow apparatus should deliver the same fuel rail pressure as specified for the vehicle.

2. A light hydrocarbon (isooctane, mineral spirits or Stoddard solvent) should be used for flow testing. The intent is for each lab to continue a consistent practice.

3. Hold the injector open wide for ten seconds. A longer time interval may risk overheating the injector solenoid. The timing interval must be precise, and reported to hundredths of a second. Bosch indicates injectors will open fully at 8 volts DC without risk of overheating, which would allow longer flow times to improve measurement accuracy.

4. A minimum of three repeat flow rate tests per injector are considered necessary. If necessary, additional tests must be run until repeat results have less than 1% variability. 1% variability is a reasonable expectation for new injectors. The average (to two decimal places) should be reported as the flow rate for that injector measurement.

   An alternate technique that may improve measurement precision is to flow test injectors against a clean reference injector. Duplicate flow tests have shown standard deviations less than 0.1%. Also, the test injectors are subjected to less volume of testing fluids.

5. Injectors should be rated as soon as possible after removal from the vehicle to avoid drying out and possible effects on deposit stability. If any extended storage becomes necessary, the injectors should be put in a tightly sealed glass container.

6. For clean injectors at the start of each test, run the Injector Leak Rate Test to check for leaking, dribbling, etc. (See page B-9.) As injectors become fouled, the probability of pintle leakage increases. Deposit formation may cause an improper seal between pintle and injector opening, thus causing leakage.

   Upper production limit of leakage with air is 2cc per min. (at approx. 50 psig). Injectors above this rate should be rejected for test.

   To avoid unnecessary rejection of new injectors due to dirt particles, the injectors should be first flowed with liquid. This will serve to flush the critical internal areas before leak testing with air.

7. Rate injectors every 1000 miles.

8. For new injectors, flow rates within a test set for an engine should fall within ±2% of each other.

Temperature Measurement

Each laboratory should measure:

1. Ambient at test site (maximum and minimum for every 24 hour time period).
2. Injector tips.
3. Inlet air, coolant, oil and fuel tank.

For items 2 and 3, report typical maximum temperatures during operations for each 24 hour test period.

Injectors with thermocouples should be installed as follows:

No. of Engine Cylinders	Thermocouple Injector Location
4	Cylinder #1
6 or 8	Cylinder #1 and a second cylinder as chosen by each test lab.

A service to install thermocouples on flowed injectors supplied by each participant is available through:

Mr. Earl Grates
13214 Culver
Utica, MI 48087

Phone: (313)986-1912 (call after 4:00 p.m.)

Cost is $50/installation to be covered by each participant. A type K thermocouple will be used and a six inch lead with a connector will be attached.

Fuel Consumption

For each test, the fuel consumed per odometer miles traveled should be recorded with reasonable accuracy. Use of a standard gasoline dispensing pump is satisfactory. One Average per test program is a representative measurement.

PRESENTATION OF DATA

Each laboratory is requested to provide the following in their final report:

1. Total number of soak cycles.

2. Tabulation of raw flow rates for each injector by cylinder position.

3. Number of soak cycles for each 1000 mile interval.

4. Graphs of flow rates vs. vehicle miles per car per fuel. In order to expedite coordination of results, each laboratory is asked to plot graphs using the following coordinates:
   a. X-axis (vehicle miles) - 0 to 6000 in increments of 1000.
   b. Y-axis (flow rates - g/sec) - 3.6 to 2.0 in increments of 0.1 for Chryslers' cars, 2.9 to 1.8 in increments of 0.1 for GM cars. (Above subject to change only if results exceed specified values.)

5. Graphs of % flow restrictions for each injector per car per tankful.
   a. X-axis - same as 2a.
   b. Y-axis - 30 to 0 in increments of 1.

Standardized data sheets will be issued to the participants prior to testing. A Lotus spreadsheet for reporting of data will be available for those interested.

It is recognized that some companies desire to make interim injector pressure drop measurements without removing injectors. If a laboratory's experience shows a close correlation between these measurements and actual flow rates and vehicle performance, these supplemental data should be reported. However, the primary data required are actual injector flow rate measurements at the beginning, at each 1,000 mile interval and at the end of the testing.

INJECTOR LEAK RATE TEST PROCEDURE

1. Blow any residual fluids out of the injector with clean, dry shop air while holding the injector open.

2. While the injector is still open, rinse with acetone and blow dry. Repeat.

3. Mount injector in rig and attach hypodermic needle assembly as in the diagram.

4. Place a 5 ml, water-filled syringe over the hypodermic needle tip for gas collection and volumetric measurements at 0.25, 1.0 and 5.0 ml. Immerse in bath as illustrated.

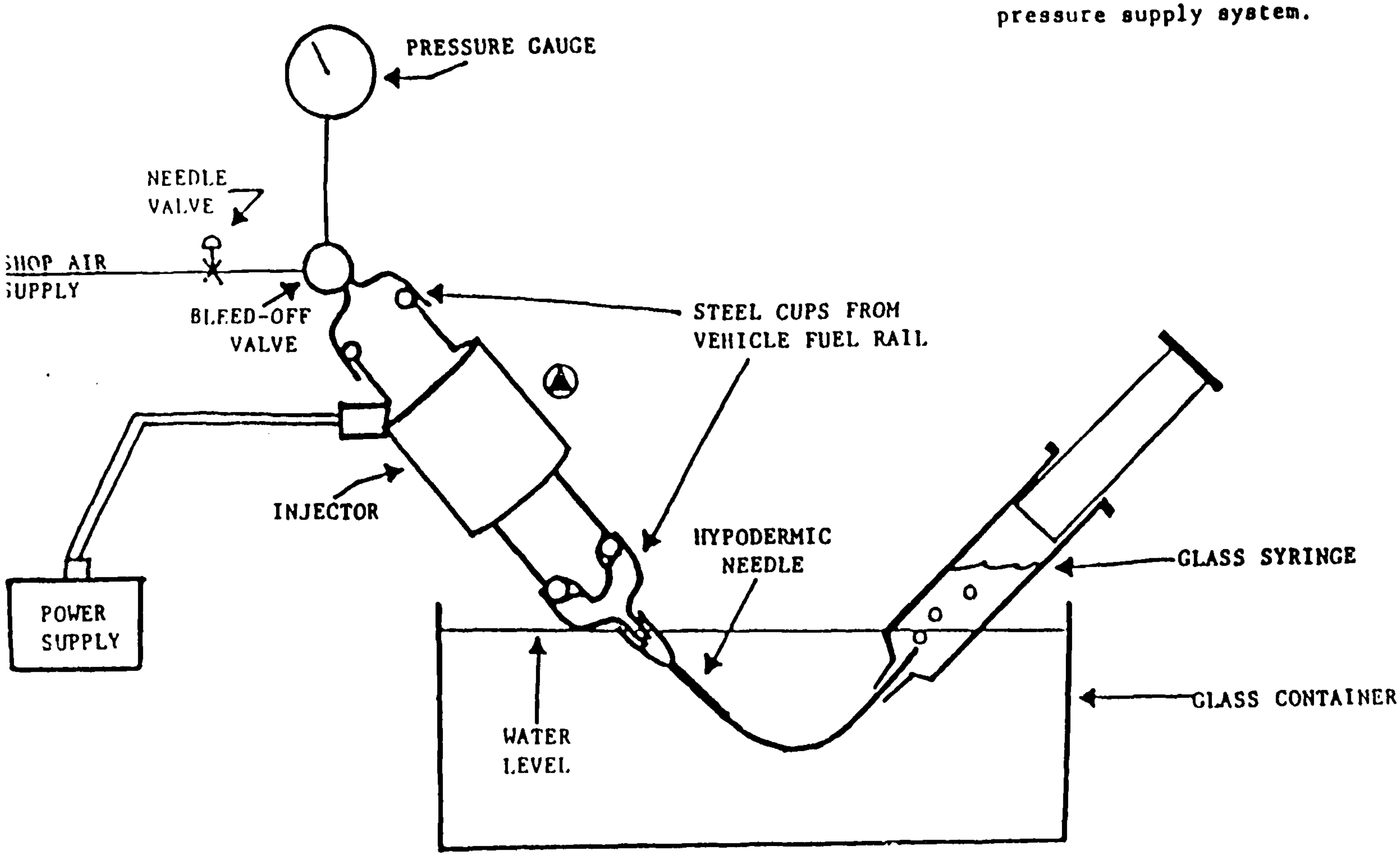
5. Apply 50 PSI air pressure and collect the air bubbles at the hypodermic needle tip using the 5 ml syringe measured over a suitable time period.

6. Record results as ml's of air collected per one minute time period.

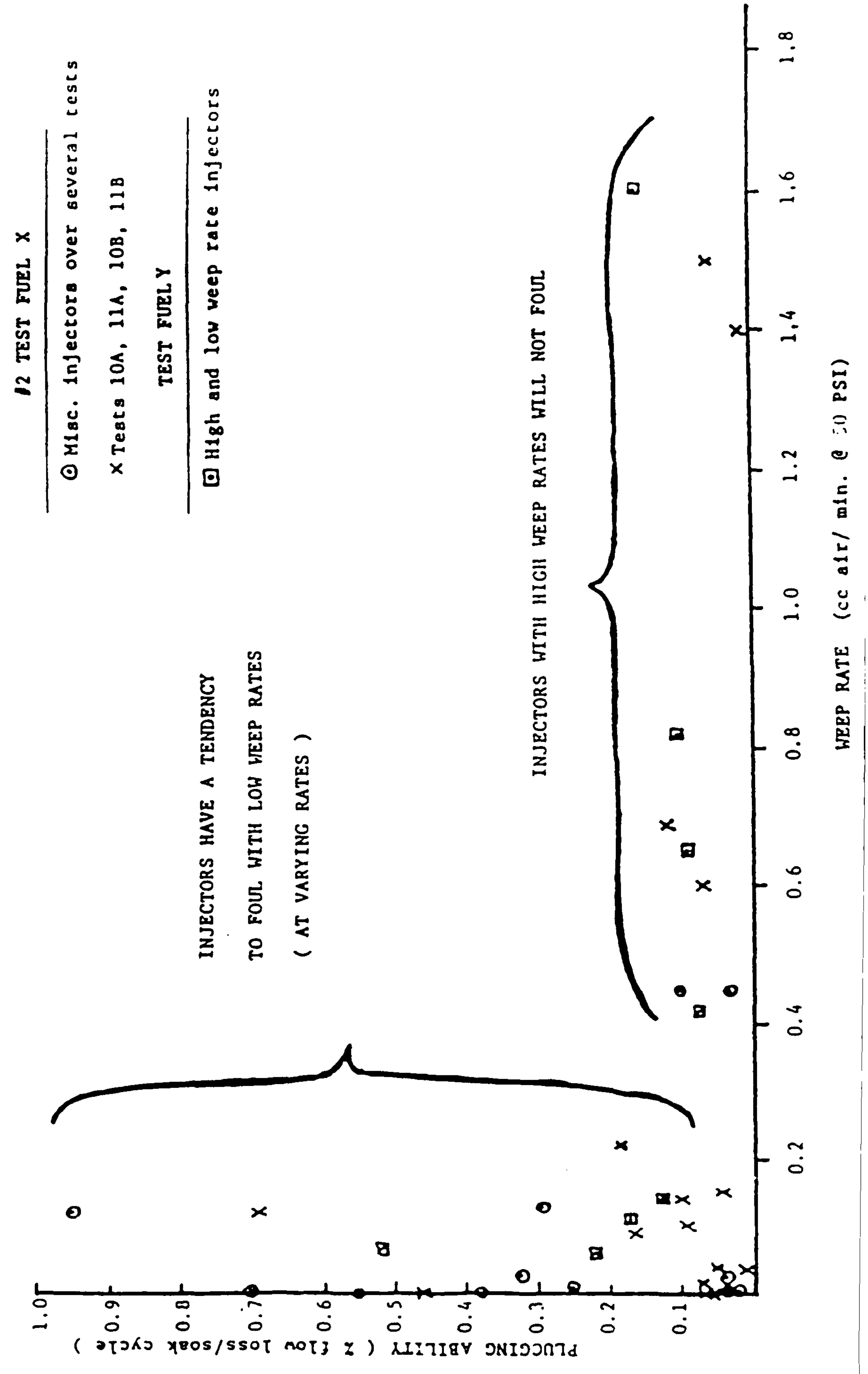
7. Repeat until 3 consecutive results in the same range are obtained.

INJECTOR LEAK TEST APPARATUS

NOT SHOWN: A clamping device which holds the injector body into the air pressure supply system.



INJECTOR PLUGGING vs. WEEP RATE



APPENDIX C

VEHICLE DESCRIPTIONS
AND
PROGRAM SUMMARY

Table C-I
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
VEHICLE DESCR PTIONS AND PROGRAM SUMMARY

Run	Lab	Car	Fuel	Reps	Code	VEHICLE DESCRIPTION Year	Make	Model	Trans	A/C?	Cyls	Disp. L	Turbo?	Comp. Ratio	Start Date	End Date	Days Run	Total Soak Cycles	Total Miles	Cycles per 1000 mi.	Cycles per 1000 km	FUEL ECONOMY mi/gal.	FUEL CONSUMP. L/100-km
(1)	1	D1	A	1/3	1D1-A1	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	10-Nov-86	03-Dec-86	24	236	2830	83.4	51.7	21.2	11.1
(2)	1	D1	A	2/3	1D1-A2	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	15-Dec-86	23-Jan-87	40	360	4455	80.8	50.1	21.4	10.9
(3)	1	D1	A	3/3	1D1-A3	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	15-Oct-87	08-Dec-87	55	309	3091	100.0	62.0		
(4)	1	D2	C	1/1	1D2-C	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	27-Oct-86	11-Dec-86	46	497	5987	83.0	51.5	21.8	10.8
(5)	2	D	A	1/1	2D-A	1984	D	E	Auto	Yes	4	2.2	Yes	8.5				408	5995	68.1	42.2	31.9	7.4
(6)	2	D	C	1/1	2D-C	1984	D	E	Auto	Yes	4	2.2	Yes	8.5				409	6000	68.2	42.3		
(7)	2	G	A	1/2	2G-A1	1985	G	O	Auto	Yes	6	3.8	No					415	6000	69.2	42.9	31.3	7.5
(8)	2	G	A	2/2	2G-A2	1985	G	O	Auto	Yes	6	3.8	No					205	2994	68.5	42.5	32.0	7.3
(9)	2	G	C	1/1	2G-C	1985	G	O	Auto	Yes	6	3.8	No					423	5998	70.5	43.7		
(10)	3	G	A	1/2	3G-A1	1986	G	T	Auto	Yes	6	3.8	No	8.5	04-Mar-87	25-Mar-87	22	445	6007	74.1	45.9		
(11)	3	G	A	2/2	3G-A2	1986	G	T	Auto	Yes	6	3.8	No	8.5	11-Jun-87	22-Jul-87	42	451	6185	72.9	45.2		
(12)	3	G	C	1/1	3G-C	1986	G	T	Auto	Yes	6	3.8	No	8.5	20-Apr-87	08-May-87	19	435	6014	72.3	44.8		
(13)	3	G	B	1/1	3G-B	1986	G	T	Auto	Yes	6	3.8	No	8.5	23-Mar-87	16-Apr-87	25	431	6013	71.7	44.4		
(14)	4	L1	A	1/1	4L1-A	1986	L	P	Auto	Yes	8	5.0	No	8.9	26-May-87	17-Aug-87	84	607	6067	100.0	62.0	20.2	11.6
(15)	4	L2	A	1/1	4L2-A	1986	L	P	Auto	Yes	8	5.0	No	8.9	05-Sep-87	11-Oct-87	37	607	6068	100.0	62.0	19.7	11.9
(16)	5	G	A	1/1	5G-A	1986	G	T	Auto	Yes	6	3.8	No	8.5	09-Apr-87	28-Apr-87	20	354	5262	67.3	41.7		
(17)	5	G	C	1/1	5G-C	1986	G	T	Auto	Yes	6	3.8	No	8.5	29-Apr-87	22-May-87	24	411	6007	68.4	42.4		
(18)	6	D1	A	1/1	6D1-A	1984	D	Y	Auto	Yes	4	2.2	Yes	8.5	30-Jul-87	10-Aug-87	12	228	3000	76.0	47.1	13.2	17.8
(19)	6	D2	B	1/1	6D2-B	1984	D	Y	Auto	Yes	4	2.2	Yes	8.5	06-Aug-87	27-Aug-87	22	455	6008	75.7	47.0	13.2	17.8
(20)	7	F1	A	1/1	7F1-A	1985	F	R	Auto	Yes	8	5.0	No	9.5	12-Nov-86	08-Dec-86	27	219	3007	72.8	45.2	25.6	9.2
(21)	7	F1	C	1/2	7F1-C1	1985	F	R	Auto	Yes	8	5.0	No	9.5	05-Jan-87	19-Feb-87	46	438	6016	72.8	45.1	28.9	8.1
(22)	7	F1	C	2/2	7F1-C2	1985	F	R	Auto	Yes	8	5.0	No	9.5	24-Feb-87	13-Apr-87	49	436	6001	72.7	45.0	25.5	9.2
(23)	7	F2	A	1/2	7F2-A1	1985	F	R	Auto	Yes	8	5.0	No	9.5	12-Nov-86	09-Dec-86	28	219	3013	72.7	45.1	25.8	9.1
(24)	7	F2	A	2/2	7F2-A2	1985	F	[illegible]	Auto	Yes	8	5.0	No	9.5	24-Feb-87	13-Mar-87	18	218	3002	72.6	45.0	21.4	11.0
(25)	7	F2	C	1/1	7F2-C	1985	F		Auto	Yes	8	5.0	No	9.5	05-Jan-87	19-Feb-87	46	437	6010	72.7	45.1	28.6	8.2
(26)	7	F2	B	1/1	7F2-B	1985	F	R	Auto	Yes	8	5.0	No	9.5	02-Sep-87	12-Nov-87	72	436	6002	72.6	45.0	32.8	7.2
(27)	8	D	A	1/2	8D-A1	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	15-Dec-86	04-Mar-87	80	321	4000	80.3	49.8	23.9	9.8
(28)	8	D	A	2/2	8D-A2	1985	D	H	Auto	Yes	4	2.2	Yes	8.5	11-Mar-87	16-Apr-87	37	317	4001	79.2	49.1	24.9	9.4
(29)	9	F1	A	1/1	9F1-A	1986	F	R	Auto	Yes	8	5.0	No	9.3	Dec-86		31	231	3000	77.0	47.7		
(30)	9	F1	C	1/1	9F1-C	1986	F	R	Auto	Yes	8	5.0	No	9.3	Jan-87		28	154	2000	77.0	47.7	21.6	10.9
(31)	9	F2	A	1/1	9F2-A	1986	F	R	Auto	Yes	8	5.0	No	9.3	Dec-86		23	231	3000	77.0	47.7	22.4	10.5
(32)	9	F2	C	1/1	9F2-C	1986	F	R	Auto	Yes	8	5.0	No	9.3	Jan-87		28	231	3000	77.0	47.7	18.9	12.4
(33)	10	D	A	1/1	10D-A	1985	D	J	Auto	Yes	4	2.2	Yes	8.5	01-Dec-86	09-Dec-86	9	143	1998	71.6	44.4	20.6	11.4
(34)	10	D	C	1/1	10D-C	1985	D	J	Auto	Yes	4	2.2	Yes	8.5	09-Dec-86	12-Jan-87	35	430	6000	71.7	44.4	21.7	10.8
(35)	11	D	A	1/3	11D-A1	1986	D	H	Auto	Yes	4	2.2	Yes	8.5	16-Jan-87	13-Feb-87	29	291	2954	98.5	61.1	23.8	9.9
(36)	11	D	A	2/3	11D-A2	1986	D	H	Auto	Yes	4	2.2	Yes	8.5	13-May-87	13-Jul-87	62	579	5994	96.6	59.9	22.7	10.3
(37)	11	D	A	3/3	11D-A3	1986	D	H	Auto	Yes	4	2.2	Yes	8.5	27-Oct-87	10-Dec-87	45	387	4029	96.1	59.6		
(38)	11	D	C	1/1	11D-C	1986	D	H	Auto	Yes	4	2.2	Yes	8.5	26-Mar-87	12-May-87	48	485	5009	96.8	60.0	23.3	10.1

Table C-1
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
VEHICLE DESCRIPTIONS AND PROGRAM SUMMARY
(Continued)

						VEHICLE DESCRIPTION																	
Run	Lab	Car	Fuel	Reps	Code	Year	Make	Model	Trans	A/C?	Cyls	Disp. L	Turbo?	Comp. Ratio	Start Date	End Date	Days Run	Total Soak Cycles	Total Miles	Cycles per 1000 mi.	Cycles per 1000 km	FUEL ECONOMY mi/gal.	FUEL CONSUMP. L/100-km
(39)	12	D	A	1/1	EXCLUDED*	1985	D	J	Auto	Yes	4	2.2	Yes	8.5	06-Feb-87	24-Mar-87	47	401	6021	66.6	41.3		
(40)	12	D	C	1/1	EXCLUDED*	1985	D	J	Auto	Yes	4	2.2	Yes	8.5	24-Mar-87	24-Apr-87	32	400	6002	66.6	41.3		
(41)	12	S	A	1/1	EXCLUDED*	1986	S	W	Auto	Yes	6	2.8	No	9.2	07-Feb-87	20-Mar-87	42	400	6000	66.7	41.3		
(42)	12	S	C	1/1	EXCLUDED*	1986	S	W	Auto	Yes	6	2.8	No	9.2	26-Mar-87	07-May-87	43	400	6006	66.6	41.3		

* Data Incomplete

APPENDIX D

TEST FUEL INSPECTIONS

Table D-I
FUEL A ANALYSIS

(Start/End of Test)

Laboratory	Existent Gum, D 381 Unwashed mg/100 mL	Existent Gum, D 381 Washed mg/100 mL	Induction Period D 525 minutes	Reid Vapor Pressure psi (kPa)	Distillation, D 86, C IBP	10%	50%	90%	EP
1	4.4 / -	3.8 / -	- / -	12.5 / - (86)/ -	28 / -	45 / -	104 / -	188 / -	221 / -
2	10.0 /17.0	4.8 /11.2	216 / -	12.6 /12.0 (87)/ (82)	26 / 22	43 / 36	101 / 94	177 / 174	224 / 212
3	10.0 /17.2	1.9 / 5.0	240 / 210	12.0 /12.0 (82)/ (82)	31 / 33	46 / 47	103 / 103	180 / 184	226 / 219
4	9.0 / 5.8	4.0 / 5.6	255 / 255	10.1 / 8.1 (69)/ (56)	32 / 36	50 / 51	103 / 106	182 / 182	220 / 223
5	17.0 /21.0	11.0 /15.0	282 / 212	12.3 /12.1 (85)/ (83)	27 / 29	43 / 44	102 / 101	182 / 184	218 / 222
6	14.8 /15.6	3.4 / 3.8	290 / 295	- / -	30 / 32	44 / 47	103 / 101	192 / 196	215 / 217
7	5.2 /11.2	3.0 / 9.2	- / -	- / -	31 / 29	47 / 47	105 / 105	185 / 185	222 / 223
8	8.8 / 8.3	2.4 / 4.6	240 / 265	12.0 /12.0 (82)/ (82)	25 / 24	44 / 44	102 / 103	187 / 186	223 / 222
9	7.0 / 4.2	6.0 / 3.0	270 / 150	11.9 /11.1 (82)/ (76)	32 / 28	48 / 46	106 / 108	188 / 192	218 / 218
10	13.8 /14.2	4.1 / 3.8	285 / 300	12.3 /11.6 (85)/ (80)	26 / 29	41 / 43	99 / 100	179 / 177	222 / 216
11	5.0 / 8.0	3.0 / 5.0	240 / 180	- / -	32 / 29	44 / 45	102 / 104	179 / 181	227 / 227

Table D-II
FUEL B ANALYSIS

(Start/End of Test)

Laboratory	Existent Gum, D 381		Induction Period D 525 minutes	Reid Vapor Pressure psi (kPa)	Distillation, D 86, C				
	Unwashed mg/100 mL	Washed mg/100 mL			IBP	10%	50%	90%	EP
3	3.8 / -	0.6 / -	360+/ -	8.9 / - (61)/ -	37 / -	57 / -	103 / -	162 / -	205 / -
6	2.2 / 2.6	0.2 / 0.6	- / -	- / -	39 / 37	59 / 61	111 / 112	175 / 177	202 / 204
7	3.8 / -	1.0 / -	- / -	- / -	33 / -	55 / -	104 / -	162 / -	199 / -

Table D-III
FUEL C ANALYSIS

(Start/End of Test)

Laboratory	Existent Gum, D 381		Induction Period D 525 minutes	Reid Vapor Pressure psi (kPa)	Distillation, D 86, C				
	Unwashed mg/100 mL	Washed mg/100 mL			IBP	10%	50%	90%	EP
1	0.4 / -	0.4 / -	- / -	7.7 / - (53)/	34 / -	54 / -	104 / -	157 / -	219 / -
2	0.4 / 0.8	0.3 / 0.6	1485 / -	7.5 / 7.6 (52)/ (52)	38 / 30	55 / 53	108 / 107	167 / 164	227 / 218
3	2.0 / 3.8	0.1 / 2.0	360+/ 360+	7.5 / 7.5 (52)/ (52)	35 / 39	53 / 57	106 / 109	180 / 170	214 / 217
5	2.0 / 2.0	1.0 / 1.0	1200 /1200	8.1 / 8.0 (56)/ (55)	35 / 36	53 / 52	106 / 107	169 / 167	221 / 218
7	1.0 / 0.8	0.6 / 0.4	- / -	- / -	39 / 38	58 / 57	112 / 111	174 / 172	222 / 222
9	- / 6.0	- / 1.6	- /1410+	- / 6.9 / (47)	- / 37	- / 56	- / 111	- / 177	- / 215
10	3.2 / 1.9	0.2 / 0.4	No / No Break Break	7.2 / 6.6 (49)/ (45)	36 / 36	53 / 56	105 / 108	166 / 168	218 / 211
11	2.0 / 2.0	1.0 / 2.0	1440+/ -	- / 6.3 (43)	34 / 37	57 / 60	109 / 111	165 / 169	229 / 226

APPENDIX E

LABORATORY OPERATING CONDITIONS

TABLE E-I

METHOD OF TESTING
BY PARTICIPATING LABORATORIES

LAB	LOCATION FOR ACCUMULATING CYCLES * 15-Minute Run Segment	LOCATION FOR ACCUMULATING CYCLES * 45-Minute Soak Segment	COMMENTS
1	Outdoors on Road	Outdoors (Days) Indoors (Nights)	
2	Indoors on CD	Indoors	Used hood shield to elevate injector temperature (Run 8, Car Make G, Fuel A)
3	Outdoors on Sheltered MAD	Outdoors on Sheltered MAD	Rail pressure decreases were detected during Run (12). Regulator and fuel pump were replaced during next run (11) but min pressures remained low.
4	Outdoors on Road	Enclosure at 21 C	
5	Outdoors on MAD	Outdoors on MAD	
6	Outdoors on MAD	Outdoors on MAD	
7	Outdoors on MAD	Outdoors on MAD	
8	Outdoors on Road	Indoors (Heated Garage)	
9	Outdoors on MAD	Outdoors on MAD	
10	Outdoors on MAD	Outdoors on MAD	
11	Outdoors on Road	Outdoors	
12	Outdoors on MAD	Outdoors on MAD	

* CD = Chassis Dynamometer, Dual Roll Type
MAD = Mileage Accumulation Dynamometer, Single Roll Type

APPENDIX F

INJECTOR FLOW DATA

MASTER DATA SET

LAB 1

Table F-1
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(1)	1	D1	A	1/3	Nov-86	24	0	0	0	3.49	3.53	3.50	3.50					3.51	0.0	0.0	0.0	0.0					0.0	0.0
							1000	919	76	3.29	2.78	3.41	3.29					3.19	5.7	21.2	2.6	6.0					8.9	21.2
Code = 1D1-A1							2000	1860	156	3.06	2.17	3.36	3.24					2.96	12.3	38.5	4.0	7.4					15.6	38.5
					EOT ------>		3000	2830	236	2.77	2.23	3.27	3.18					2.86	20.6	36.8	6.6	9.1					18.3	36.8
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.52	0.00	0.00	0.94					0.37										
(2)	1	D1	A	2/3	Dec-86	40	0	0	0	3.48	3.46	3.46	3.49					3.47	0.0	0.0	0.0	0.0					0.0	0.0
							1000	978	80	3.38	3.45	3.42	3.48					3.43	2.9	0.3	1.2	0.3					1.2	2.9
Code = 1D1-A2							2000	2095	152	3.05	3.38	3.36	3.45					3.31	12.4	2.3	2.9	1.1					4.7	12.4
							3000	3251	248	2.68	3.16	3.31	3.39					3.14	23.0	8.7	4.3	2.9					9.7	23.0
					EOT ------>		4000	4455	360	2.65	2.96	3.25	3.37					3.06	23.9	14.5	6.1	3.4					12.0	23.9
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.84	0.00	0.00	0.00					0.21										
(3)	1	D1	A	3/3	Oct-87	55	0	0	0	3.51	3.52	3.43	3.45					3.48	0.0	0.0	0.0	0.0					0.0	0.0
							1000	1063	106	3.48	3.48	3.44	3.38					3.45	0.7	1.0	-0.3	1.8					0.8	1.8
Code = 1D1-A3							2000	2141	214	3.19	3.34	3.35	2.31					3.05	9.2	5.1	2.3	33.0					12.4	33.0
					EOT ------>		3000	3091	309	2.96	3.09	3.31	2.16					2.88	15.6	12.2	3.6	37.2					17.1	37.2
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.																					
(4)	1	D2	C	1/1	Oct-86	46	0	0	0	3.48	3.49	3.46	3.50					3.48	0.0	0.0	0.0	0.0					0.0	0.0
							1000	985	76	3.43	3.48	3.41	3.41					3.43	1.4	0.3	1.4	2.6					1.4	2.6
Code = 1D2-C							2000	1963	161	3.37	3.47	3.29	3.38					3.38	3.2	0.6	4.9	3.4					3.0	4.9
							3000	2931	241	3.31	3.49	3.28	3.38					3.37	4.9	0.0	5.2	3.4					3.4	5.2
							4000	3864	320	3.26	3.47	3.25	3.36					3.34	6.3	0.6	6.1	4.0					4.2	6.3
							5000	4820	401	3.26	3.46	3.22	3.37					3.33	6.3	0.9	6.9	3.7					4.5	6.9
					EOT ------>		6000	5987	497	3.26	3.47	3.22	3.39					3.34	6.3	0.6	6.9	3.1					4.2	6.9
							Leak Test, ml-air/min.			0.00	0.00	0.00	0.00					0.00										

LAB 2

Table F-II
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(5)	2	D	A	1/1			0	0	0	2.89	2.82	2.81	2.84					2.84	0.0	0.0	0.0	0.0					0.0	0.0
Code = 2D-A							1000	998	67	2.83	2.82	2.83	2.81					2.82	2.1	0.0	-0.7	1.1					0.6	2.1
							2000	2001	136	2.67	2.68	2.74	2.75					2.71	7.6	5.0	2.5	3.2					4.6	7.6
							3000	3003	204	2.57	2.64	2.71	2.74					2.67	11.1	6.4	3.6	3.5					6.1	11.1
							4000	3996	272	2.37	2.63	2.66	2.78					2.61	18.0	6.7	5.3	2.1					8.0	18.0
							5000	4995	340	2.64	2.53	2.60	2.67					2.61	8.7	10.3	7.5	6.0					8.1	10.3
					EOT ------>		6000	5995	408	2.74	2.60	2.62	2.69					2.66	5.2	7.8	6.8	5.3					6.3	7.8
							Leak Test, ml-air/min.			0.30	0.05	0.10	1.70					0.54										
(6)	2	D	C	1/1			0	0	0	3.04	2.92	2.99	2.98					2.98	0.0	0.0	0.0	0.0					0.0	0.0
Code = 2D-C							1000	1000	68	2.98	2.93	2.97	2.98					2.97	2.0	-0.3	0.7	0.0					0.6	2.0
							2000	2000	136	2.98	2.95	2.97	2.97					2.97	2.0	-1.0	0.7	0.3					0.5	2.0
							3000	3001	204	2.97	2.83	2.97	3.01					2.95	2.3	3.1	0.7	-1.0					1.3	3.1
							4000	4000	272	2.98	2.83	2.91	2.90					2.91	2.0	3.1	2.7	2.7					2.6	3.1
							5000	5000	340	2.91	2.79	2.94	2.95					2.90	4.3	4.5	1.7	1.0					2.9	4.5
					EOT ------>		6000	6000	409	2.85	2.83	2.91	2.96					2.89	6.2	3.1	2.7	0.7					3.2	6.2
							Leak Test, ml-air/min.																					
(7)	2	G	A	1/2			0	0	0	2.29	2.29	2.31	2.33	2.30	2.31			2.31	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
Code = 2G-A1							1000	991	68	2.26	2.35	2.20	2.36	2.29	2.30			2.29	1.3	-2.6	4.8	-1.3	0.4	0.4			0.5	4.8
							2000	1991	136	2.25	2.21	2.10	2.26	2.24	2.30			2.23	1.7	3.5	9.1	3.0	2.6	0.4			3.4	9.1
							3000	2999	205	2.19	2.13	2.02	2.23	2.15	2.30			2.17	4.4	7.0	12.6	4.3	6.5	0.4			5.9	12.6
							4000	3995	275	2.09	2.12	1.97	2.21	2.12	2.20			2.12	8.7	7.4	14.7	5.2	7.8	4.8			8.1	14.7
							5000	4998	344	1.77	2.05	1.95	2.15	2.04	2.09			2.01	22.7	10.5	15.6	7.7	11.3	9.5			12.9	22.7
					EOT ------>		6000	6000	415	1.80	1.99	1.92	1.93	2.01	1.93			1.93	21.4	13.1	16.9	17.2	12.6	16.5			16.3	21.4
							Leak Test, ml-air/min.			0.01	0.01	0.03	0.05	0.01	0.01			0.02										
(8)	2	G	A	2/2			0	0	0	2.37	2.37	2.37	2.37	2.44	2.30			2.37	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
Code = 2G-A2							1000	1000	68	2.05	1.85	2.05	2.37	2.30	2.34			2.16	13.5	21.9	13.5	0.0	5.7	-1.7			8.8	21.9
							2000	1998	136	1.92	1.41	1.57	2.30	2.22	2.38			1.97	19.0	40.5	33.8	3.0	9.0	-3.5			17.0	40.5
					EOT ------>		3000	2994	205	1.71	1.42	1.48	2.26	2.08	2.32			1.88	27.8	40.1	37.6	4.6	14.8	-0.9			20.7	40.1
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.																					
(9)	2	G	C	1/1			0	0	0	2.36	2.44	2.50	2.43	2.44	2.37			2.42	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
Code = 2G-C							1000	1000	70	2.41	2.37	2.36	2.44	2.37	2.36			2.39	-2.1	2.9	5.6	-0.4	2.9	0.4			1.5	5.6
							2000	1988	138	2.35	2.37	2.40	2.44	2.36	2.37			2.38	0.4	2.9	4.0	-0.4	3.3	0.0			1.7	4.0
							3000	2999	210	2.31	2.30	2.30	2.40	2.30	2.34			2.33	2.1	5.7	8.0	1.2	5.7	1.3			4.0	8.0
							4000	4002	280	2.43	2.37	2.43	2.43	2.30	2.36			2.39	-3.0	2.9	2.8	0.0	5.7	0.4			1.5	5.7
							5000	4993	352	2.22	2.25	2.26	2.29	2.14	2.21			2.23	5.9	7.8	9.6	5.8	12.3	6.8			8.0	12.3
					EOT ------>		6000	5998	423	2.37	2.31	2.37	2.44	2.29	2.35			2.36	-0.4	5.3	5.2	-0.4	6.1	0.8			2.8	6.1
							Leak Test, ml-air/min.																					

LAB 3

Table F-III
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(10)	3	G	A	1/2	Mar-87	17	0	0	0	2.11	2.07	2.12	2.09	2.13	2.09			2.10	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	974	70	2.11	1.99	2.10	2.05	2.14	2.10			2.08	0.0	3.9	0.9	1.9	-0.5	-0.5			1.0	3.9
Code = 3G-A1							2000	2224	161	1.96	1.98	2.06	1.99	2.09	2.04			2.02	7.1	4.3	2.8	4.8	1.9	2.4			3.9	7.1
							3000	3021	219	1.87	1.90	1.99	1.92	2.04	1.97			1.95	11.4	8.2	6.1	8.1	4.2	5.7			7.3	11.4
							4000	4002	290	1.76	1.89	1.93	1.91	2.03	1.96			1.91	16.6	8.7	9.0	8.6	4.7	6.2			9.0	16.6
							5000	4996	362	1.68	1.88	1.86	1.85	1.98	1.94			1.87	20.4	9.2	12.3	11.5	7.0	7.2			11.3	20.4
					EOT ------>		6000	6007	445	1.42	1.83	1.80	*	1.92	1.81			1.46	32.7	11.6	15.1		9.9	13.4			16.5	32.7
													* Injector Malfunction															
							Leak Test, ml-air/min.			0.04	0.80	0.70	0.64	0.10	0.00			0.38										
(11)	3	G	A	2/2	Apr-87	19	0	0	0	2.29	2.21	2.21	2.22	2.23	2.21			2.23	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	1019	71	2.30	2.17	2.23	2.20	2.19	2.20			2.21	-0.2	[illegible]	-1.0	0.7	1.8	0.6			0.6	1.9
Code = 3G-A2							2000	2009	142	2.23	2.12	2.18	2.16	2.15	2.17			2.17	2.9	4.1	1.4	2.8	3.5	1.8			2.8	4.1
							3000	3019	217	2.19	2.09	2.11	2.11	2.09	2.14			2.12	4.5	5.8	4.6	4.8	6.1	3.2			4.8	6.1
							4000	4028	289	2.17	2.06	2.03	2.08	2.01	2.08			2.07	5.6	7.1	7.9	6.4	9.8	5.8			7.1	9.8
							5000	5003	363	2.13	2.03	1.98	2.08	2.00	1.99			2.03	7.1	8.5	10.4	6.4	10.1	10.2			8.8	10.4
					EOT ------>		6000	6185	451	2.09	1.99	1.78	2.05	1.94	1.98			1.97	8.8	10.1	19.5	7.6	12.7	10.6			11.5	19.5
							Leak Test, ml-air/min.			0.03	0.15	0.07	0.07	0.09	0.10			0.09										
(12)	3	G	C	1/1	Mar-87	25	0	0	0	2.39	2.42	2.33	2.33	2.32	2.33			2.35	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	967	71	2.20	2.31	2.24	2.30	2.25	2.25			2.26	7.9	4.4	3.9	1.3	2.9	3.3			4.0	7.9
Code = 3G-C							2000	[illegible]	150	2.13	2.26	2.15	2.27	2.22	2.20			2.21	10.9	6.5	7.8	2.6	4.2	5.4			6.2	10.9
							3000	3002	218	2.12	2.27	2.13	2.26	2.23	2.24			2.21	11.3	6.0	8.7	3.0	3.8	3.7			6.1	11.3
							4000	4015	288	2.12	2.27	2.12	2.27	2.24	2.25			2.21	11.3	6.0	9.1	2.6	3.3	3.3			5.9	11.3
							5000	5004	360	2.07	2.23	2.03	2.26	2.22	2.18			2.17	13.4	7.7	13.0	3.0	4.2	6.3			7.9	13.4
					EOT ------>		6000	6014	435	2.03	2.19	1.91	2.22	2.18	2.14			2.11	15.1	9.4	18.1	4.8	5.9	8.0			10.2	18.1
							Leak Test, ml-air/min.			0.85	0.07	0.36	0.25	0.70	0.01			0.37										
(13)	3	G	B	1/1	Jun-87	27	0	0	0	2.26	2.23	2.18	2.27	2.25	2.25			2.24	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	1029	74	2.27	2.22	2.19	2.27	2.25	2.25			2.24	-0.5	0.6	-0.5	0.0	0.3	-0.4			-0.1	0.6
Code = 3G-B							2000	2009	143	2.26	2.23	2.20	2.29	2.27	2.27			2.25	0.0	0.1	-1.0	-0.9	-0.9	-0.9			-0.6	0.1
							3000	3251	232	2.24	2.19	2.18	2.27	2.24	2.23			2.23	0.8	1.8	-0.1	-0.1	0.7	0.5			0.6	1.8
							4000	4135	296	2.21	2.19	2.19	2.26	2.24	2.27			2.23	2.3	1.7	-0.2	0.3	0.6	-1.1			0.6	2.3
							5000	5094	365	2.17	2.15	2.17	2.25	2.23	2.23			2.20	4.2	3.5	0.7	0.7	1.1	0.8			1.8	4.2
					EOT ------>		6000	6013	431	2.15	2.15	2.16	2.26	2.18	2.24			2.19	5.1	3.7	1.1	0.3	3.2	0.5			2.3	5.1
							Leak Test, ml-air/min.			0.67	0.94	0.82	0.75	0.72	0.73			0.77										

LAB 4

Table F-IV
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(14)	4	L1	A	1/1	May-87	84	0	0	0	1.64	1.59	1.61	1.58	1.60	1.60	1.58	1.59	1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Code = 4L1-A							1000	1011	101	1.62	1.61	1.60	1.59	1.60	1.59	1.53	1.59	1.59	1.2	-1.3	0.6	-0.6	0.0	0.6	3.2	0.0	0.5	3.2
							2000	2011	201	1.58	1.60	1.58	1.56	1.60	1.55	1.45	1.58	1.56	3.7	-0.6	1.9	1.3	0.0	3.1	8.2	0.6	2.3	8.2
							3000	3036	304	1.55	1.57	1.59	1.53	1.59	1.50	1.43	1.58	1.54	5.5	1.3	1.2	3.2	0.6	6.3	9.5	0.6	3.5	9.5
							4000	4064	406	1.53	1.54	1.59	1.49	1.59	1.54	1.38	1.58	1.53	6.7	3.1	1.2	5.7	0.6	3.8	12.7	0.6	4.3	12.7
							5000	5066	507	1.49	1.49	1.60	1.42	1.59	1.54	1.38	1.57	1.51	9.1	6.3	0.6	10.1	0.6	3.8	12.7	1.3	5.6	12.7
					EOT ------>		6000	6067	607	1.46	1.46	1.57	1.49	1.53	1.54	1.47	1.57	1.51	11.0	8.2	2.5	5.7	4.4	3.8	7.0	1.3	5.5	11.0
							Leak Test, ml-air/min.																					
(15)	4	L2	A	1/1	Sep-87	37	0	0	0	1.61	1.59	1.60	1.60	1.60	1.61	1.61	1.62	1.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Code = 4L2-A							1000	1006	101	1.61	1.58	1.60	1.60	1.60	1.60	1.61	1.62	1.60	0.0	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.2	0.6
							2000	2001	200	1.58	1.51	1.57	1.57	1.55	1.57	1.58	1.61	1.57	1.9	5.0	1.9	1.9	3.1	2.5	1.9	0.6	2.3	5.0
							3000	3043	304	1.54	1.46	1.51	1.53	1.54	1.50	1.53	1.53	1.52	4.3	8.2	5.6	4.4	3.8	6.8	5.0	5.6	5.5	8.2
							4000	4050	405	1.57	1.43	1.53	1.53	1.54	1.51	1.57	1.58	1.53	2.5	10.1	4.4	4.4	3.8	6.2	2.5	2.5	4.5	10.1
							5000	5036	504	1.58	1.46	1.51	1.50	1.53	1.48	1.57	1.57	1.53	1.9	8.2	5.6	6.3	4.4	8.1	2.5	3.1	5.0	8.2
					EOT ------>		6000	6068	607	1.58	1.40	1.53	1.54	1.53	1.47	1.57	1.58	1.53	1.9	11.9	4.4	3.8	4.4	8.7	2.5	2.5	5.0	11.9
							Leak Test, ml-air/min.																					

LAB 5

Table F-V
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(16)	5	G	A	1/1	Apr-87	20	0	0	0	2.27	2.31	2.30	2.24	2.29	2.18			2.27	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	983	66	2.11	2.27	2.24	2.12	2.14	2.14			2.17	7.0	1.7	2.6	5.4	6.6	1.8			4.2	7.0
	Code = 5G-A						2000	1971	133	1.95	2.23	2.18	2.10	1.99	2.06			2.09	14.1	3.5	5.2	6.3	13.1	5.5			7.9	14.1
							3000	2999	201	1.77	2.15	2.17	2.03	1.90	2.03			2.01	22.0	6.9	5.7	9.4	17.0	6.9			11.3	22.0
							4000	4018	270	1.95	2.16	2.24	1.97	1.94	2.03			2.05	14.1	6.5	2.6	12.1	15.3	6.9			9.6	15.3
							5000	5010	338	1.96	2.13	2.20	1.97	1.91	1.98			2.03	13.7	7.8	4.3	12.1	16.6	9.2			10.6	16.6
					EOT ------>		6000	5262	354	1.96	2.08	2.16	1.67	1.70	1.88			1.91	13.7	10.0	6.1	25.4	25.8	13.8			15.8	25.8
							Leak Test, ml·air/min.			0.50	0.60	0.60	0.90	1.90	0.90			0.90										
(17)	5	G	C	1/1	Apr-87	24	0	0	0	2.25	2.29	2.31	2.27	2.28	2.23			2.27	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
							1000	1009	69	2.14	2.28	2.28	2.24	2.23	2.21			2.23	4.9	0.4	1.3	1.3	2.2	0.9			1.8	4.9
	Code = 5G-C						2000	1999	137	2.04	2.26	2.24	2.14	2.04	2.14			2.14	9.3	1.3	3.0	5.7	10.5	4.0			5.7	10.5
							3000	2945	206	1.84	2.24	2.22	2.08	1.94	2.09			2.07	18.2	2.2	3.9	8.4	14.9	6.3			9.0	18.2
							4000	3996	274	1.94	2.20	2.25	2.03	1.92	2.05			2.07	13.8	3.9	2.6	10.6	15.8	8.1			9.1	15.8
							5000	5004	343	1.93	2.09	2.22	1.98	1.87	2.00			2.02	14.2	8.7	3.9	12.8	18.0	10.3			11.3	18.0
					EOT ------>		6000	6007	411	1.93	2.06	2.20	1.74	1.72	1.91			1.93	14.2	10.0	4.8	23.3	24.6	14.3			15.2	24.6
							Leak Test, ml·air/min.			0.60	0.60	0.50	0.80	0.90	0.60			0.67										

LAB 6

Table F-VI
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(18)	6	D1	A	1/1	Jul-87	12	0	0	0	3.35	3.38	3.39	3.38					3.38	0.0	0.0	0.0	0.0					0.0	0.0
							1000	1000	76	3.23	3.16	3.34	3.03					3.19	3.6	6.5	1.5	10.4					5.5	10.4
Code = 6D1-A							2000	2000	152	3.13	3.09	3.24	2.66					3.03	6.6	8.6	4.4	21.3					10.2	21.3
					EOT ------->		3000	3000	228	3.03	2.99	3.19	1.93					2.79	9.6	11.5	5.9	42.9					17.5	42.9
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.																					
(19)	6	D2	B	1/1	Aug-87	22	0	0	0	3.37	3.36	3.40	3.31					3.36	0.0	0.0	0.0	0.0					0.0	0.0
							1000	1000	76	3.35	3.36	3.39	3.32					3.36	0.6	0.0	0.3	-0.3					0.1	0.6
Code = 6D2-B							2000	2000	152	3.34	3.35	2.84	3.30					3.21	0.9	0.3	16.5	0.3					4.5	16.5
							3000	2998	227	3.37	3.36	3.19	3.31					3.31	0.0	0.0	6.2	0.0					1.5	6.2
							4000	4005	303	3.36	3.33	3.04	3.29					3.26	0.3	0.9	10.6	0.6					3.1	10.6
							5000	5004	379	3.35	3.33	2.94	3.31					3.23	0.6	0.9	13.5	0.0					3.8	13.5
					EOT ------->		6000	6008	455	3.34	3.32	2.88	3.30					3.21	0.9	1.2	15.3	0.3					4.4	15.3
							Leak Test, ml-air/min.																					

LAB 7

Table F-VIIa
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(20)	7	F1	A	1/1	Nov-86	27	0	0	0	2.28	2.31	2.32	2.30	2.32	2.29	2.29	2.28	2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1009	73	1.84	1.93	2.02	2.19	1.93	2.04	2.21	2.05	2.03	19.3	16.5	12.9	4.8	16.8	10.9	3.5	10.1	11.8	19.3
Code = 7F1-A							2000	2025	147	1.73	1.81	2.09	2.12	1.48	1.91	2.13	1.78	1.88	24.1	21.6	9.9	7.8	36.2	16.6	7.0	21.9	18.2	36.2
					EOT ------>		3000	3007	219	1.68	1.69	2.12	2.07	1.21	1.82	2.08	1.63	1.79	26.3	26.8	8.6	10.0	47.8	20.5	9.2	28.5	22.2	47.8
							4000																					
							5000																					
							6000																					
						SOT	Leak Test, ml-air/min.			1.52	1.11	0.97	0.40	1.20	0.72	0.61	0.90	0.93										
						EOT	Leak Test, ml-air/min.			0.77	5.00	0.65	0.10	0.80	5.00	0.72	4.90	2.24										
(21)	7	F1	C	1/2	Jan-87	46	0	0	0	2.27	2.25	2.26	2.27	2.29	2.31	2.33	2.23	2.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1018	74	2.25	2.26	2.24	2.20	2.25	2.22	2.32	2.00	2.22	0.9	-0.4	0.9	3.1	1.7	3.9	0.4	10.3	2.6	10.3
Code = 7F1-C1							2000	2011	146	2.23	2.24	2.25	2.23	1.98	1.98	2.28	1.90	2.14	1.8	0.4	0.4	1.8	13.5	14.3	2.1	14.8	6.1	14.8
							3000	3013	219	2.14	2.16	2.13	2.16	1.67	1.67	2.22	1.55	1.96	5.7	4.0	5.8	4.8	27.1	27.7	4.7	30.5	13.8	30.5
							4000	4006	291	2.19	2.23	2.19	2.13	1.75	1.52	2.19	1.42	1.95	3.5	0.9	3.1	6.2	23.6	34.2	6.0	36.3	14.2	36.3
							5000	5006	364	2.17	2.18	2.15	2.14	1.73	1.70	2.23	1.36	1.96	4.4	3.1	4.9	5.7	24.5	26.4	4.3	39.0	14.0	39.0
					EOT ------>		6000	6016	438	2.15	2.17	2.17	2.17	1.76	1.76	2.20	1.33	1.96	5.3	3.6	4.0	4.4	23.1	23.8	5.6	40.4	13.8	40.4
						SOT	Leak Test, ml-air/min.			0.15	0.01	0.40	0.40	0.05	0.95	0.00	0.80	0.35										
						EOT	Leak Test, ml-air/min.			0.32	0.10	0.25	0.35	0.60	0.55	0.10	1.00	0.41										
(22)	7	F1	C	2/2	Feb-87	49	0	0	0	2.19	2.23	2.21	2.23	2.21	2.19	2.18	2.19	2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1010	73	2.11	2.13	2.18	2.20	2.19	2.01	1.79	2.16	2.10	3.7	4.5	1.4	1.3	0.9	8.2	17.9	1.4	4.9	17.9
Code = 7F1-C2							2000	2007	145	1.98	2.11	2.17	2.18	2.16	2.15	2.14	2.21	2.14	9.6	5.4	1.8	2.2	2.3	1.8	1.8	-0.9	3.0	9.6
							3000	3001	218	1.94	1.94	2.19	2.17	2.12	2.09	2.07	2.15	2.08	11.4	13.0	0.9	2.7	4.1	4.6	5.0	1.8	5.4	13.0
							4000	4004	291	1.98	1.81	2.17	2.14	2.14	2.07	2.05	2.16	2.07	9.6	18.8	1.8	4.0	3.2	5.5	6.0	1.4	6.3	18.8
							5000	5010	364	1.68	1.62	2.16	2.16	2.10	2.03	2.05	2.16	1.99	23.5	27.5	2.4	3.1	4.9	7.3	5.9	1.4	9.5	27.5
					EOT ------>		6000	6001	436	1.66	1.77	2.13	2.14	2.10	1.97	1.99	2.13	1.99	24.4	20.5	3.5	4.3	4.8	10.2	8.7	2.9	9.9	24.4
						SOT	Leak Test, ml-air/min.			0.20	1.00	0.50	0.50	0.10	0.70	1.90	1.10	0.75										
						EOT	Leak Test, ml-air/min.			0.63	0.65	0.25	0.70	0.50	1.30	0.80	0.45	0.66										
(23)	7	F2	A	1/2	Nov-86	28	0	0	0	2.29	2.26	2.31	2.28	2.32	2.32	2.33	2.32	2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1010	73	1.84	1.93	2.02	2.19	1.93	2.04	2.21	2.05	2.03	19.7	14.6	12.6	3.9	16.8	12.1	5.2	11.6	12.1	19.7
Code = 7F2-A1							2000	2009	146	1.96	2.08	1.83	2.06	1.55	1.79	1.87	2.01	1.89	14.4	8.0	20.8	9.6	33.2	22.8	19.7	13.4	17.7	33.2
					EOT ------>		3000	3013	219	1.73	1.98	1.49	2.01	1.26	1.72	1.76	2.00	1.74	24.5	12.4	35.5	11.8	45.7	25.9	24.5	13.8	24.2	45.7
							4000																					
							5000																					
							6000																					
						SOT	Leak Test, ml-air/min.			2.56	0.30	1.25	1.10	0.90	1.66	1.10	0.75	1.20										
						EOT	Leak Test, ml-air/min.			1.80	0.05	0.80	0.50	0.61	0.90	0.32	0.40	0.67										

LAB 7 (Continued)

Table F-VIIb
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(24)	7	F2	A	2/2	Feb-87	18	0	0	0	2.21	2.22	2.20	2.23	2.21	2.23	2.23	2.23	2.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1002	73	1.98	1.97	1.86	1.88	1.71	2.16	1.79	2.03	1.92	10.4	11.3	15.5	15.7	22.6	3.1	19.7	9.0	13.4	22.6
Code = 7F2-A2							2000	2007	146	1.79	1.74	1.64	1.79	1.63	2.15	1.72	1.96	1.80	19.0	21.6	25.5	19.7	26.2	3.6	22.9	12.1	18.8	26.2
					EOT ------>		3000	3002	218	1.72	1.53	1.59	1.80	1.65	2.12	1.71	1.96	1.76	22.2	31.1	27.7	19.3	25.3	4.9	23.3	12.1	20.7	31.1
							4000																					
							5000																					
							6000																					
						SOT	Leak Test, ml-air/min.			0.65	0.25	1.80	0.85	1.40	0.40	1.10	1.20	0.96										
						EOT	Leak Test, ml-air/min.			1.10	1.25	0.50	0.63	0.35	0.45	0.38	0.25	0.61										
(25)	7	F2	C	1/1	Jan-87	46	0	0	0	2.29	2.29	2.28	2.33	2.30	2.29	2.27	2.28	2.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1014	74	2.12	2.11	2.03	2.33	2.25	2.22	2.05	2.06	2.15	7.4	7.9	11.0	0.0	2.2	3.1	9.7	9.6	6.4	11.0
Code = 7F2-C							2000	2006	146	1.63	1.91	1.74	2.30	2.21	2.15	1.81	1.99	1.97	28.8	16.6	23.7	1.3	3.9	6.1	20.3	12.7	14.2	28.8
							3000	3005	219	1.65	1.67	1.50	2.20	2.10	2.07	1.53	1.82	1.82	27.9	27.1	34.2	5.6	8.7	9.6	32.6	20.2	20.7	34.2
							4000	4006	291	1.73	1.57	1.53	2.19	2.09	2.06	1.48	1.70	1.79	24.4	31.4	32.9	6.0	9.1	10.0	34.8	25.4	21.8	34.8
							5000	5005	365	1.66	1.44	1.55	2.20	2.12	2.08	1.31	1.63	1.75	27.5	37.1	32.0	5.6	7.8	9.2	42.3	28.5	23.8	42.3
					EOT ------>		6000	6010	437	1.61	1.31	1.54	2.18	2.05	2.08	1.15	1.48	1.68	29.7	42.8	32.5	6.4	10.9	9.2	49.3	35.1	27.0	49.3
						SOT	Leak Test, ml-air/min.			0.10	1.75	1.00	0.20	0.05	0.20	0.70	0.50	0.56										
						EOT	Leak Test, ml-air/min.			0.85	1.70	0.70	0.20	0.00	0.50	1.40	1.50	0.86										
(26)	7	F2	B	1/1	Sep-87	72	0	0	0	2.24	2.22	2.25	2.22	2.23	2.22	2.20	2.22	2.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1008	73	2.17	2.15	2.18	2.14	2.18	2.16	2.18	2.19	2.17	3.5	3.3	3.0	3.7	2.2	2.3	0.8	1.3	2.5	3.7
Code = 7F2-B							2000	2003	145	2.05	2.02	2.01	2.03	2.06	2.00	2.05	2.08	2.04	8.7	9.1	10.4	8.4	7.5	9.7	7.0	6.5	8.4	10.4
							3000	3005	218	2.23	2.24	2.23	2.19	2.17	2.13	2.19	2.20	2.20	0.6	-0.8	0.9	1.2	2.6	4.1	0.7	0.8	1.2	4.1
							4000	4009	291	2.18	2.18	2.19	2.17	2.17	2.17	2.19	2.20	2.18	3.0	1.6	2.5	2.4	2.6	2.3	0.5	0.9	2.0	3.0
							5000	5008	363	2.18	2.17	2.18	2.14	2.14	2.13	2.18	2.20	2.16	2.6	2.2	2.8	3.4	4.0	4.1	1.2	1.1	2.7	4.1
					EOT ------>		6000	6002	436	2.16	2.20	2.17	2.15	2.17	2.15	2.20	2.23	2.18	3.5	0.9	3.4	3.0	2.6	3.0	0.1	-0.4	2.0	3.5
						SOT	Leak Test, ml-air/min.			0.00	0.40	0.00	0.95	0.05	0.00	0.45	0.00	0.23										
						EOT	Leak Test, ml-air/min.			0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.13										

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Table F-VIII
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(27)	8	D	A	1/2	Dec-86	80	0	0	0	3.44	3.43	3.44	3.44					3.44	0.0	0.0	0.0	0.0					0.0	0.0
Code = 8D-A1							1000	1001	80	3.41	3.38	3.31	3.35					3.36	0.9	1.5	3.8	2.6					2.2	3.8
							2000	2062	165	3.35	3.24	3.04	3.22					3.21	2.6	5.5	11.6	6.4					6.5	11.6
							3000	2999	241	3.26	3.07	3.00	3.20					3.13	5.2	10.5	12.8	7.0					8.9	12.8
					EOT ------->		4000	4000	321	3.10	2.83	2.87	3.12					2.98	9.9	17.5	16.6	9.3					13.3	17.5
							5000																					
							6000																					
							Leak Test, ml-air/min.			1.34	0.73	1.87	0.25					1.05										
(28)	8	D	A	2/2	Mar-87	37	0	0	0	3.40	3.43	3.37	3.47					3.42	0.0	0.0	0.0	0.0					0.0	0.0
Code = 8D-A2							1000	999	79	3.36	3.38	3.29	3.35					3.35	1.2	1.5	2.4	3.5					2.1	3.5
							2000	2003	159	3.20	3.21	3.16	3.11					3.17	5.9	6.4	6.2	10.4					7.2	10.4
							3000	3001	238	3.00	2.99	3.00	2.86					2.96	11.8	12.8	11.0	17.6					13.3	17.6
					EOT ------->		4000	4001	317	2.84	2.78	2.79	2.62					2.76	16.5	19.0	17.2	24.5					19.3	24.5
							5000																					
							6000																					
							Leak Test, ml-air/min.			1.33	1.03	1.32	1.21					1.22										

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Table F-IX
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(29)	9	F1	A	1/1	Dec-86	31	0	0	0	2.35	2.30	2.33	2.38	2.39	2.34	2.36	2.34	2.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1000	77	2.30	2.27	1.97	2.34	2.10	2.31	2.09	2.17	2.19	2.1	1.3	15.5	1.7	12.1	1.3	11.4	7.3	6.6	15.5
	Code = 9F1-A						2000	2000	154	2.26	2.00	1.76	2.22	1.83	2.26	1.97	1.96	2.03	3.8	13.0	24.5	6.7	23.4	3.4	16.5	16.2	13.5	24.5
					EOT ------>		3000	3000	231	2.28	1.54	1.18	2.18	1.68	2.22	1.68	1.62	1.80	3.0	33.0	49.4	8.4	29.7	5.1	28.8	30.8	23.5	49.4
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
(30)	9	F1	C	1/1	Jan-87	28	0	0	0	2.25	2.27	2.28	2.32	2.32	2.33	2.31	2.31	2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1000	77	1.64	1.76	2.30	2.24	1.81	2.17	2.30	2.34	2.07	27.1	22.5	-0.9	3.4	22.0	6.9	0.4	-1.3	10.0	27.1
	Code = 9F1-C				EOT ------>		2000	2000	154	1.29	1.10	2.28	2.26	1.33	1.95	2.12	2.31	1.83	42.7	51.5	0.0	2.6	42.7	16.3	8.2	0.0	20.5	51.5
							3000																					
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.																					
(31)	9	F2	A	1/1	Dec-86	23	0	0	0	2.32	2.34	2.33	2.31	2.33	2.33	2.40	2.41	2.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1000	77	2.20	2.28	2.30	2.28	2.15	2.25	2.31	2.33	2.26	5.2	2.6	1.3	1.3	7.7	3.4	3.7	3.3	3.6	7.7
	Code = 9F2-A						2000	2000	154	1.98	2.10	2.26	2.17	2.17	2.24	2.30	2.20	2.18	14.7	10.3	3.0	6.1	6.9	3.9	4.2	8.7	7.2	14.7
					EOT ------>		3000	3000	231	1.26	1.79	1.80	2.01	1.80	1.72	2.20	2.20	1.85	45.7	23.5	22.7	13.0	22.7	26.2	8.3	8.7	21.4	45.7
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
(32)	9	F2	C	1/1	Jan-87	28	0	0	0	2.28	2.29	2.31	2.32	2.31	2.32	2.35	2.30	2.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							1000	1000	77	2.19	2.18	2.24	2.18	2.12	2.17	2.14	2.19	2.18	3.9	4.8	3.0	6.0	8.2	6.5	8.9	4.8	5.8	8.9
	Code = 9F2-C						2000	2000	154	2.20	2.15	2.29	2.12	1.70	2.04	2.11	2.17	2.10	3.5	6.1	0.9	8.6	26.4	12.1	10.2	5.7	9.2	26.4
					EOT ------>		3000	3000	231	2.25	2.11	2.31	2.10	1.60	1.62	1.86	2.12	2.00	1.3	7.9	0.0	9.5	30.7	30.2	20.9	7.8	13.5	30.7
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.																					

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Table F-X
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

							MILEAGE ACCUMULATION			INJECTOR FLOW RATES (g/sec.)									PERCENT FLOW REDUCTION (FROM NEW)									
Run	Lab	Car	Fuel	Reps	Start Date	Days Run	Target	Actual	Cycles	1	2	3	4	5	6	7	8	AVG	1	2	3	4	5	6	7	8	AVG	WORST
(33)	10	D	A	1/1	Dec-86	9	0	0	0	3.29	3.27	3.27	3.29					3.28	0.0	0.0	0.0	0.0					0.0	0.0
							1000	990	70	2.59	2.84	2.68	3.15					2.82	21.3	13.1	18.0	4.3					14.2	21.3
Code = 10D-A					EOT ------>		2000	1998	143	2.42	2.55	2.24	2.96					2.54	26.4	22.0	31.5	10.0					22.5	31.5
							3000																					
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.23	0.22	0.93	0.00					0.35										
(34)	10	D	C	1/1	Dec-86	35	0	0	0	3.29	3.29	3.27	3.28					3.28	0.0	0.0	0.0	0.0					0.0	0.0
							1000	982	71	3.15	3.04	3.12	3.12					3.11	4.3	7.6	4.6	4.9					5.3	7.6
Code = 10D-C							2000	1995	143	3.08	2.78	3.07	2.86					2.95	6.4	15.5	6.1	12.8					10.2	15.5
							3000	3013	217	2.99	2.75	2.95	2.99					2.92	9.1	16.4	9.8	8.8					11.0	16.4
							4000	4001	288	3.04	2.56	3.08	2.83					2.88	7.6	22.2	5.8	13.7					12.3	22.2
							5000	5003	359	2.99	2.42	3.05	2.75					2.80	9.1	26.4	6.7	16.2					14.6	26.4
					EOT ------>		6000	6000	430	2.85	2.39	3.04	2.85					2.78	13.4	27.4	7.0	13.1					15.2	27.4
							Leak Test, ml-air/min.			0.00	0.43	0.00	0.07					0.13										

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Table F-XI
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(35)	11	D	A	1/3	Jan-87	29	0	0	0	3.46	3.45	3.46	3.46					3.46	0.0	0.0	0.0	0.0					0.0	0.0
Code = 11D-A1							1000	953	94	3.43	3.40	3.15	3.43					3.35	0.8	1.6	9.1	0.8					3.1	9.1
							2000	1916	188	2.89	3.39	2.82	3.40					3.13	16.5	1.8	18.7	1.7					9.7	18.7
					EOT ------>		3000	2954	291	2.10	3.38	2.39	3.36					2.81	39.3	2.1	31.0	3.0					18.9	39.3
							4000																					
							5000																					
							6000																					
							Leak Test, ml-air/min.			0.00	0.00	0.01	0.01					0.01										
(36)	11	D	A	2/3	May-87	62	0	0	0	3.44	3.47	3.43	3.42					3.44	0.0	0.0	0.0	0.0					0.0	0.0
Code = 11D-A2							1000	1000	97	3.39	3.39	3.29	3.34					3.35	1.4	2.4	4.0	2.4					2.5	4.0
							2000	1981	192	3.30	3.34	3.27	3.28					3.30	4.2	3.8	4.8	4.1					4.2	4.8
							3000	2996	290	3.16	3.31	3.24	3.22					3.23	8.2	4.8	5.7	5.8					6.1	8.2
							4000	3999	386	3.04	3.30	3.21	3.06					3.15	11.6	5.1	6.4	10.7					8.5	11.6
							5000	4990	484	2.95	3.29	3.20	2.94					3.10	14.3	5.4	6.8	13.9					10.1	14.3
					EOT ------>		6000	5994	579	2.81	3.27	3.18	2.84					3.03	18.2	6.0	7.3	17.0					12.1	18.2
							Leak Test, ml-air/min.																					
(37)	11	D	A	3/3	Oct-87	45	0	0	0	3.46	3.47	3.46	3.48					3.47	0.0	0.0	0.0	0.0					0.0	0.0
Code = 11D-A3							1000	919	88	3.29	3.09	3.30	3.44					3.28	4.8	10.9	4.7	1.0					5.4	10.9
							2000	2019	195	3.30	3.01	3.04	3.40					3.19	4.8	13.2	12.2	2.3					8.1	13.2
							3000	2946	284	3.26	3.16	3.16	3.34					3.23	5.8	9.1	8.9	3.9					6.9	9.1
					EOT ------>		4000	4029	387	3.18	3.16	3.05	3.26					3.16	8.2	8.9	12.0	6.2					8.8	12.0
							5000																					
							6000																					
							Leak Test, ml-air/min.																					
(38)	11	D	C	1/3	Mar-87	48	0	0	0	3.45	3.49	3.50	3.48					3.48	0.0	0.0	0.0	0.0					0.0	0.0
Code = 11D-C							1000	1000	97	3.45	3.47	3.18	3.43					3.38	0.0	0.6	9.0	1.4					2.8	9.0
							2000	1994	193	3.45	3.44	3.08	2.84					3.20	0.0	1.4	12.0	18.2					7.9	18.2
							3000	3004	291	3.44	3.40	2.96	2.84					3.16	0.4	2.6	15.4	18.4					9.2	18.4
							4000	3985	386	3.44	3.37	2.86	2.88					3.14	0.4	3.4	18.2	17.1					9.8	18.2
					EOT ------>		5000	5009	485	3.43	3.32	2.75	2.87					3.09	0.7	4.9	21.5	17.3					11.1	21.5
							6000																					
							Leak Test, ml-air/min.																					

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Table F-XII
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
MASTER FLOW DATA SET

Run	Lab	Car	Fuel	Reps	Start Date	Days Run	MILEAGE ACCUMULATION Target	Actual	Cycles	INJECTOR FLOW RATES (g/sec.) 1	2	3	4	5	6	7	8	AVG	PERCENT FLOW REDUCTION (FROM NEW) 1	2	3	4	5	6	7	8	AVG	WORST
(39)	12	D	A	1/1	Feb-87	47	0	0	0	3.40	3.40	3.37	3.44					3.40										
							1000	1169	78																			
EXCLUDED							2000	2180	145																			
FROM							3000	3540	236																			
ANALYSIS							4000	4590	306																			
AND							5000																					
FIGURES					EOT ------>		6000	6021	401	3.19	3.08	2.85	2.92					3.01	6.3	9.2	15.3	15.0					11.5	15.3
						SOT	Leak Test, ml-air/min.			0.51	0.96	0.16	0.12					0.44										
						EOT	Leak Test, ml-air/min.			0.43	0.79	0.03	0.10					0.34										
(40)	12	D	C	1/1	Mar-87	32	0	0	0	3.41	3.42	3.46	3.44					3.43										
							1000	1034	69																			
EXCLUDED							2000	2000	133																			
FROM							3000	3124	208																			
ANALYSIS							4000	4255	284																			
AND							5000	5345	356																			
FIGURES					EOT ------>		6000	6002	400	3.12	2.97	3.21	2.83					3.03	8.5	13.1	7.2	17.9					11.7	17.9
						SOT	Leak Test, ml-air/min.			0.00	0.00	0.03	0.13					0.04										
						EOT	Leak Test, ml-air/min.			0.00	0.00	0.10	0.60					0.17										
(41)	12	S	A	1/1	Feb-87	42	0	0	0	2.07	2.08	2.05	2.08	2.09	2.06			2.07										
							1000	1166	78																			
EXCLUDED							2000	2200	147																			
FROM							3000	3205	214																			
ANALYSIS							4000	4200	280																			
AND							5000	5000	333																			
FIGURES					EOT ------>		6000	6006	400	1.95	1.94	2.07	2.04	2.00	1.93			1.99	5.6	6.6	-1.0	2.1	4.6	6.3			4.0	6.6
						SOT	Leak Test, ml-air/min.			0.44	1.60	0.34	0.22	0.01	0.35			0.49										
						EOT	Leak Test, ml-air/min.			0.12	0.73	0.08	0.15	0.20	0.02			0.22										
(42)	12	S	C	1/1	Mar-87	43	0	0	0	2.07	2.07	2.06	2.07	2.07	2.07			2.07										
							1000	1166	78																			
EXCLUDED							2000	2200	147																			
FROM							3000	3205	214																			
ANALYSIS							4000	4200	280																			
AND							5000	5000	333																			
FIGURES					EOT ------>		6000	6006	400	2.03	2.05	2.03	2.02	2.04	2.06			2.04	1.8	1.1	1.3	2.3	1.6	0.3			1.4	2.3
						SOT	Leak Test, ml-air/min.			1.23	0.25	0.70	0.29	0.10	0.55			0.52										
						EOT	Leak Test, ml-air/min.			0.39	0.01	0.09	0.45	0.04	0.17			0.19										

APPENDIX G

TEMPERATURE DATA

LAB 1

Table G-I
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(1)	1	D1	A	1D1-A1																									
(2)	1	D1	A	1D1-A2	29-Dec-86	21	11									100					330	69	52	212					48
(3)	1	D1	A	1D1-A3																									
(4)	1	D2	C	1D2-C																									

LAB 2

Table G-II
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	Injector Tip Soak Temperatures, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(5)	2	D	A	2D-A	28-Jan-87	21	19									91	32	96				70	67	195	90	204			
(6)	2	D	C	2D-C																									
(7)	2	G	A	2G-A1	10-Feb-87	22	21									56	48	96				72	70	132	118	204			
(8)	2	G	A	2G-A2	24-Feb-87 (w/ shield)	21	21									82	52	97				70	69	180	125	206			
(9)	2	G	C	2G-C																									

LAB 3

Table G-IIIa
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa		Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi	
(10)	3	G	A	3G-A1	04-Mar-87	27	19									89	49	95	111	62	227	179	81	66	192	120	203	232	144	33	26
					05-Mar-87	26	14									88	51	94	110	62			79	57	190	124	201	230	144		
					09-Mar-87	28	21									86	51	100	105	61			82	70	187	124	212	221	142		
					10-Mar-87	24	16									89	49	98	111	59			75	61	192	120	208	232	138		
					11-Mar-87	18	17									82	42	96	106	55			64	63	180	108	205	223	131		
					12-Mar-87	21	12									85	44	98	105	57			70	54	185	111	208	221	135		
					13-Mar-87	23	15									78	43	93	99	55			73	59	172	109	199	210	131		
					16-Mar-87	24	21									88	49	101	110	62			75	70	190	120	214	230	144		
					17-Mar-87	26	18									89	51	100	111	63			79	64	192	124	212	232	145		
					18-Mar-87	29	15									93	67	102	113	66	220	179	84	59	199	153	216	235	151	32	26
					19-Mar-87	27	17									92	56	100	113	66			81	63	198	133	212	235	151		
					20-Mar-87	28	20									88	53	99	112	65			82	68	190	127	210	234	149		
(11)	3	G	A	3G-A2	11-Jun-87	33										90	-18	99	111	-18			91		194		210	232			
					12-Jun-87	33	28									95	59	100	112	66	247	62	91	82	203	138	212	234	151	36	9
					15-Jun-87	37										95	61	100	114	68	234	55	99		203	142	212	237	154	34	8
During Run 12, the rail					16-Jun-87	35	28									96	62	101	112	74	234	55	95	82	205	144	214	234	165	34	8
pressures started to					18-Jun-87	34	27									97	61	101	111	71	261	62	93	81	207	142	214	232	160	38	9
decrease more during					19-Jun-87	34	27									97	62	102	111	73	227	34	93	81	207	144	216	232	163	33	5
the soak. Thus, the					24-Jun-87	36										95	63	99	112	72	213		97		203	145	210	234	162	31	0
regulator and fuel pump					25-Jun-87	40	29									97	63	102	112	73	206		104	84	207	145	216	234	163	30	0
were replaced on 6/18,					01-Jul-87	36										97	63	99	111	72	206	82	97		207	145	210	232	162	30	12
but the minimum rail					02-Jul-87	35	29									96	62	100	110	69	220		95	84	205	144	212	230	156	32	0
pressures remained low					07-Jul-87	31	26									94	57	99	111	68	213		88	79	201	135	210	232	154	31	0
and sometimes were					08-Jul-87	31	26									94	57	100	112	68	227		88	79	201	135	212	234	154	33	0
zero.					09-Jul-87	32	24									94	58	99	112	68	220		90	75	201	136	210	234	154	32	0
					10-Jul-87	33	28									93	59	99	107	70	206	76	91	82	199	138	210	225	158	30	11
					13-Jul-87	37										94	59	99	112	68	199	76	99		201	138	210	234	154	29	11
					14-Jul-87	36	29									92	58	102	112	65	199		97	84	198	136	216	234	149	29	0
					15-Jul-87	35	27									94	60	99	110	69	199		95	81	201	140	210	230	156	29	0
					16-Jul-87	34	29									95	59	99	110	67	206		93	84	203	138	210	230	153	30	0
					17-Jul-87	34	28									95	61	99	113	71	199	62	93	82	203	142	210	235	160	29	9
					21-Jul-87	34	28									94	58	100	110	67	192	41	93	82	201	136	212	230	153	28	6
					22-Jul-87	34	29									93	56	99	112	68	206	55	93	84	199	133	210	234	154	30	8

Lab 3 continued on next page

LAB 3 (continued)

Table G-IIIb
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pres. kPa Max	Fuel Rail Pres. kPa Min	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pres. psi Max	Fuel Rail Pres. psi Min
(12)	3	G	C	3G-C	20-Apr-87	34	24									94	58	102	110	65			93	75	201	136	216	230	149		
					21-Apr-87	33	21									92	55	101	110	63			91	70	198	131	214	230	145		
					22-Apr-87	32	21									92	54	101	112	62			90	70	198	129	214	234	144		
					23-Apr-87	35	24									92	58	100	112	65			95	75	198	136	212	234	149		
					24-Apr-87	35	21									94	56	101	112	63	268	117	95	70	201	133	214	234	145	39	17
					29-Apr-87	33	26									96	59	100	110	68			91	79	205	138	212	230	154		
					30-Apr-87	31	23									95	56	99	113	66			88	73	203	133	210	235	151		
					01-May-87	28	23									94	57	100	112	66			82	73	201	135	212	234	151		
					05-May-87	32										94	57	100	111	66			90		201	135	212	232	151		
					06-May-87	28	23									92	54	101	108	64			82	73	198	129	214	226	147		
					07-May-87	31	23									94	55	100	111	64	247	48	88	73	201	131	212	232	147	36	7
					08-May-87	29	23									91	55	99	109	63	254	27	84	73	196	131	210	228	145	37	4
(13)	3	G	B	3G-B	23-Mar-87	27	20									85	49	99	112	61			81	68	185	120	210	234	142		
					24-Mar-87	26	13									85	51	98	111	63			79	55	185	124	208	232	145		
					25-Mar-87	28	17									86	50	98	112	63	220	172	82	63	187	122	208	234	145	32	25
					02-Apr-87	25	17									85	48	100	109	58			77	63	185	118	212	228	136		
					03-Apr-87	22	16									96	41	97	88	51			72	61	205	106	207	190	124		
					06-Apr-87	23	20									102	47	100	108	58			73	68	216	117	212	226	136		
					07-Apr-87	26	17									104	50	101	109	61			79	63	219	122	214	228	142		
					08-Apr-87	27	17									94	51	99	107	62			81	63	201	124	210	225	144		
					09-Apr-87	29	15									94	55	99	112	66	234	151	84	59	201	131	210	234	151	34	22
					10-Apr-87	27	16									94	46	101	106	57			81	61	201	115	214	223	135		
					13-Apr-87	30	23									94	51	99	111	62			86	73	201	124	210	232	144		
					14-Apr-87	28	16									93	51	99	109	60			82	61	199	124	210	228	140		
					15-Apr-87	32	15									94	56	100	111	65			90	59	201	133	212	232	149		
					16-Apr-87	35	19									94	56	101	110	63	247	172	95	66	201	133	214	230	145	36	25

LAB 4

Table G-IV
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	3	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(14)	4	L1	A	4L1-A	26-May-87	33	25									87					220	92	77	188					32
					27-May-87	28	23									78					220	82	74	172					32
					28-May-87	30	18									78					220	86	65	172					32
					07-Jun-87	24	21									79					220	76	70	175					32
					08-Jun-87	29	21									81					220	85	70	178					32
					10-Jun-87	28	24									82					220	82	75	179					32
					02-Jul-87	35	23									87					220	95	73	188					32
					03-Jul-87	37	30									87					220	98	86	189					32
					17-Jul-87	35	24									84					220	95	75	183					32
					18-Jul-87	35	23									88					220	95	73	190					32
					19-Jul-87	35	21									83					220	95	70	182					32
					20-Jul-87	33	20									82					220	92	68	180					32
					21-Jul-87	34	24									84					220	93	75	183					32
					28-Jul-87	33	22									87					220	92	72	188					32
					29-Jul-87	35	22									86					220	95	71	187					32
					30-Jul-87	31	22									87					220	88	72	189					32
					31-Jul-87	36	23									90					220	96	73	194					32
					01-Aug-87	36	24									87					220	97	76	189					32
					02-Aug-87	36	26									86					220	96	78	187					32
					04-Aug-87	28	22									81					220	83	72	178					32
					06-Aug-87	37	23									87					220	99	74	188					32
					07-Aug-87	37	23									89					220	99	73	193					32
					08-Aug-87	36	24									87					220	97	76	188					32
					09-Aug-87	36	23									88					220	97	73	190					32
					10-Aug-87	37	23									88					220	98	74	190					32
					16-Aug-87	38	26									88					220	100	78	190					32
					17-Aug-87	38	24									90					220	100	75	194					32
(15)	4	L2	A	4L2-A	05-Sep-87	32	22									84					220	90	72	184					32
					06-Sep-87	32	22									85					220	89	72	185					32
					08-Sep-87	34	21									86					220	93	69	186					32
					09-Sep-87	33	21									88					220	92	69	190					32
					10-Sep-87	34	20									87					179	94	68	189					26
					18-Sep-87	26	19									81					220	79	67	178					32
					19-Sep-87	29	19									83					213	85	67	182					31
					20-Sep-87	31										84					213	87		184					31
					25-Sep-87	32	17									85					179	89	62	185					26
					26-Sep-87	31	23									83					179	88	74	181					26
					27-Sep-87	33	23									86					179	92	74	186					26
					28-Sep-87	33	23									84					179	91	74	184					26
					29-Sep-87	31	13									82					179	87	55	179					26
					30-Sep-87	30										79					179	86		174					26
					07-Oct-87	30	13									83					179	86	55	182					26
					08-[illegible]-87	32	14									81					179	89	58	178					26
					09-[illegible]-87	32	16									80					206	90	60	176					30
					10-[illegible]7	31	16									81					199	87	60	177					29
					11-[illegible]	30	13									81						86	55	177					

LAB 5

Table G-V
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(16)	5	G	A	5G-A		20	7									79	21	92	104		179	68	45	175	70	198	220		26
						22	9									80	23	91	103		184	72	48	176	74	196	218		27
						21	6									77	23	93	102		183	69	43	170	73	200	215		27
						21	11									77	21	91	102		180	69	51	170	70	195	216		26
						18	8									76	20	94	104		183	65	46	168	68	202	220		27
						21	7									78	23	91	97		184	70	45	172	74	196	206		27
						21	8									77	21	93	99		179	70	46	170	70	200	210		26
						19	4									79	21	93	104		181	66	40	174	70	199	220		26
						17	4									77	18	91	99		180	62	39	170	65	195	210		26
						16	5									76	19	96	103		180	60	41	168	66	204	218		26
						17	7									78	20	92	100		180	63	45	172	68	197	212		26
						16	7									79	18	93	103		184	60	45	174	64	199	218		27
						16	9									77	19	93	98		183	61	48	170	66	199	209		27
						17	9									77	20	97	105		179	63	48	170	68	206	221		26
						17	8									80	18	91	93		180	62	47	176	65	195	200		26
						18	9									81	21	95	100		180	65	49	178	70	203	212		26
(17)	5	G	C	5G-C		21	10									80	24	93	97		180	70	50	176	75	199	206		26
						24	11									81	27	94	99		183	75	51	178	80	202	210		27
						24	9									79	27	93	106		183	76	48	175	81	200	222		27
						26	13									78	29	93	103		184	78	55	172	84	200	218		27
						27	13									78	30	93	99		184	81	56	173	86	200	210		27
						28	12									77	32	92	100		183	83	53	170	89	198	212		27
						29	14									76	31	91	99		183	85	58	169	88	196	210		27
						29	13									79	32	96	104		183	84	55	175	90	204	220		27
						27	11									81	29	93	103		183	80	52	178	85	200	218		27
						24	9									76	27	92	102		184	75	49	168	81	198	216		27
						26	14									77	30	93	104		184	78	58	170	86	200	220		27
						27	13									79	31	97	99		183	81	55	175	88	206	210		27
						27	13									79	31	91	96		183	80	55	174	87	196	204		27
						27	14									81	32	92	98		183	80	57	178	90	198	208		27
						29	16									82	33	92	103		180	85	60	180	91	198	218		26
						30	14									83	32	94	93		183	86	58	182	89	202	200		27
						29	16									80	32	93	104		183	85	60	176	90	200	220		27
						28	17									82	33	92	102		183	83	62	180	91	198	216		27
						29	16									82	31	96	99		183	84	61	180	88	204	210		27

LAB 6

Table G-VI
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(18)	6	D1	A	601-A	30-Jul-87	30	26									103	60	124	113		323	86	78	218	140	255	235		47
					31-Jul-87	30	21									103	54	128	113		330	86	70	218	130	262	235		48
					01-Aug-87	27	19									106	56	127	111		330	81	67	223	133	260	232		48
					02-Aug-87	29	23									102	52	127	112		337	85	74	215	125	260	233		49
					03-Aug-87	29	22									103	53	128	111		337	84	71	217	127	263	232		49
					04-Aug-87	30	21									104	50	129	111		323	86	69	220	122	265	232		47
					05-Aug-87	24	22									106	47	129	110		330	75	71	223	117	265	230		48
					06-Aug-87	26	16									104	61	131	110		330	78	61	220	142	268	230		48
					07-Aug-87	31	23									106	62	129	111		330	88	73	223	144	265	232		48
					08-Aug-87	26	22									106	52	131	109		323	79	71	223	125	268	228		47
					09-Aug-87	29	20									102	60	131	113		337	85	68	215	140	268	235		49
					10-Aug-87	23	20									101	49	129	107		337	73	68	213	120	265	225		49
(19)	6	D2	B	602-B	06-Aug-87	26	16									103	61	129	112		337	78	61	217	141	265	233		49
					07-Aug-87	31	23									105	62	129	113		337	88	73	221	143	265	235		49
					08-Aug-87	26	22									105	51	130	112		330	79	71	221	123	266	233		48
					09-Aug-87	29	20									100	61	126	110		330	85	68	212	141	258	230		48
					10-Aug-87	23	20									99	49	127	106		330	73	68	211	121	260	222		48
					11-Aug-87	27	16									102	47	124	113		337	80	61	216	117	255	236		49
					12-Aug-87	32	18									105	63	123	113		330	90	64	221	146	254	236		48
					13-Aug-87	33	22									103	64	123	113		330	92	71	218	148	254	236		48
					14-Aug-87	34	22									110	66	125	115		337	94	71	230	150	257	239		49
					15-Aug-87	35	22									112	67	126	113		337	95	71	233	152	258	236		49
					16-Aug-87	34	23									107	68	127	112		337	93	73	225	155	260	233		49
					17-Aug-87	28	26									102	63	126	112		330	83	78	216	146	258	233		48
					19-Aug-87	28	24									110	63	127	113		323	82	75	230	146	260	236		47
					20-Aug-87	24	19									110	63	123	113		330	76	67	230	145	254	236		48
					21-Aug-87	25	19									106	55	124	113		337	77	67	222	131	255	236		49
					22-Aug-87	25	19									100	57	127	113		337	77	67	212	134	260	236		49
					23-Aug-87	22	18									103	56	127	113		330	72	64	218	132	260	236		48
					24-Aug-87	21	13									97	55	124	110		330	69	55	206	131	255	230		48
					25-Aug-87	22	12									98	58	124	112		330	72	54	209	137	255	233		48
					26-Aug-87	18	15									97	50	125	112		330	64	59	206	122	257	233		48
					27-Aug-87	22	18									102	122	124	112		323	72	65	215	252	256	234		47

LAB 7

Table G-VII
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(20)	7	F1	A	7F1-A	Start 12-Nov-86 End 08-Dec-86	9	-13									85					300	48	9	185					44
(21)	7	F1	C	7F1-C1	Start 05-Jan-87 End 19-Feb-87	7	-25									82					300	45	-13	180					44
(22)	7	F1	C	7F1-C2	Start 24-Feb-87 End 13-Apr-87	11	-7									90					300	52	19	194					44
(23)	7	F2	A	7F2-A1	Start 12-Nov-86 End 09-Dec-86	9	-13									85	65	100	110	25	300	48	9	185	149	212	230	77	44
(24)	7	F2	A	7F2-A2	Start 24-Feb-87 End 13-Apr-87	8	-9									95	65	100	110	25	300	46	16	203	149	212	230	77	44
(25)	7	F2	C	7F2-C	Start 05-Jan-87 End 19-Feb-87	7	-25									85	65	105	115	23	300	45	-13	185	149	221	239	73	44
(26)	7	F2	B	7F2-B	Start 02-Sep-86 End 12-Nov-86	27	-4									87	65	100	105	20	300	81	25	189	149	212	221	68	44

LAB 8

Table G-VIIIa
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(27)	8	D	A	8D-A1	15-Dec-86	6										86	47		99	22		42		186	116		210	71	
					16-Dec-86	9	1									89	46	122	101	23		48	34	192	115	251	214	74	
					17-Dec-86	17	4									88	48	123	116	24	330	63	40	190	118	254	240	75	48
					18-Dec-86	6	2									82	41	121	100	16	330	42	35	179	106	249	212	61	48
					19-Dec-86	10	6									86	44	119	99	22	330	50	43	186	112	246	211	71	48
					22-Dec-86	10	3									86	43	123	99	24	330	50	37	187	110	254	210	75	48
					23-Dec-86	11	-4									88	46	123	102	24	330	52	24	191	114	253	216	75	48
					26-Dec-86	6	3									85	42		107	24	337	43	37	185	108		225	75	49
					29-Dec-86	4	-4									86	44		116	22	344	40	24	186	111		241	71	50
					30-Dec-86	9	-2									87	44		98	21	337	48	28	188	112		209	69	49
					31-Dec-86	3	1									82	46	108	114	24	337	38	33	180	114	226	238	75	49
					02-Jan-87	1	-1									81	38	118	92	12	337	33	30	177	101	244	198	54	49
					05-Jan-87	14	-1									83	42	119	111	21	330	57	30	181	108	246	231	69	48
					06-Jan-87	8	-5									81	46	122	102	24	337	47	23	178	114	251	216	75	49
					07-Jan-87	9	0									85	46	120	114	24	337	49	32	185	115	248	238	76	49
					08-Jan-87	0	-1									83	41	114	94	21	330	32	30	181	106	237	201	70	48
					12-Jan-87	0	0									84	41	117	114	29	330	32	32	183	105	242	238	85	48
					13-Jan-87	2	2									86	44	117	118	27	330	35	35	186	112	242	245	81	48
					14-Jan-87	4	-1									87	45	118	118	32	337	40	30	189	113	244	244	90	49
					15-Jan-87	13	-1									88	48	118	118	34	330	55	30	190	119	244	244	93	48
					16-Jan-87	10	2									87	45	118	121	29	330	50	35	188	113	244	250	84	48
					19-Jan-87	2	-2									82	39	121	94	23	337	36	28	179	103	249	201	73	49
					20-Jan-87	-1	-1									83	43	118	115	29	330	30	30	182	109	244	239	85	48
					21-Jan-87	6	-1									83	43	119	118	23	330	42	30	181	109	246	245	73	48
					22-Jan-87	4	-3									78	37	118	91	17	337	40	27	173	98	245	196	62	49
					27-Jan-87	-4	-12									76	34	114	109	38	330	25	10	169	94	238	228	100	48
					28-Jan-87	-7	-13									77	38	116	92	13	330	20	8	171	100	241	198	55	48
					29-Jan-87	-3	-7									80	38	119	109	16	330	27	20	176	101	247	228	61	48
					30-Jan-87	-1	-5									83	39	119	96	13	344	31	23	182	102	247	204	55	50
					31-Jan-87	-1	-5									83	41	118	109	23	344	30	23	182	105	244	229	73	50
					02-Feb-87	9	-5									87	44	121	116	24	337	49	23	189	111	249	241	75	49
					03-Feb-87	9	0									83	41	117	116	23	330	48	32	181	106	243	240	74	48
					04-Feb-87	8	-1									82	43	117	112	24	330	46	31	180	109	242	234	76	48
					05-Feb-87	0	-4									84	42	121	116	20	316	32	24	183	108	250	241	68	46
					06-Feb-87	0	-5									87	46	121	115	27	344	32	23	188	114	249	239	81	50
					07-Feb-87	9	-4									83	42	116	116	24		48	24	181	108	241	240	75	
					09-Feb-87	4	-7									76	38	114	92	17	337	40	20	169	101	238	197	63	49
					10-Feb-87	-1	-7									81	42	116	111	18	337	30	20	178	108	241	231	65	49
					11-Feb-87	2	-2									83	44	118	116	29	337	35	28	181	112	244	240	84	49
					12-Feb-87	8	-4									81	44	116	112	23	330	47	25	177	111	240	233	73	48
					13-Feb-87	-1	-2									81	43	118	112	21	350	30	28	178	109	244	233	70	51
					14-Feb-87	9	-8									80	41	114	111	18		49	18	176	106	238	231	64	
					16-Feb-87	-9	-14									73	34	113	103	17	337	15	7	164	93	235	218	62	49
					17-Feb-87	-3	-7									83	43	120	111	19	344	27	20	181	109	248	231	66	50
					18-Feb-87	2	-2										47	123	126	31	344	36	28		116	254	259	88	50
					19-Feb-87	3	-6										46	118	115	24	344	37	22		115	244	239	76	50
					20-Feb-87	11	-1										43	118	121	25	330	51	30		110	244	249	77	48
					21-Feb-87	4	-3										43	119	119	26	330	40	26		110	247	246	79	48

Lab 8, Run 27 continued on next page

LAB 8 (continued)

Table G-VIIIb
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(27)	8	D	A	8D-A1	24-Feb-87	3	-3										44	119	118	29	350	37	27		111	247	244	85	51
(continued)					25-Feb-87	5	-4										44	123	127	26	316	41	25		111	254	260	79	46
					26-Feb-87	3	-2										44	118	123	29	344	38	28		111	245	253	85	50
					27-Feb-87	5	-3										45	122	129	26	350	41	27		113	251	265	79	51
					28-Feb-87	2	-2										44	123	118	23	344	35	28		112	253	244	73	50
					02-Mar-87	13	6										46	121	127	32	330	56	42		115	250	261	89	48
					03-Mar-87	9	-1										44	121	121	32	330	48	30		112	249	249	90	48
					04-Mar-87	7	-1										44	121	123	21	344	45	30		111	249	254	69	50
(28)	8	D	A	8D-A2	11-Mar-87	2	-4									81	44	118	118	26	344	36	25	178	111	244	244	78	50
					12-Mar-87	8	-2									88	44	122	129	26		46	29	191	111	252	264	78	
					13-Mar-87	3	0									84	46	122	118	27	344	37	32	183	115	251	245	81	50
					14-Mar-87	6	-2									84	45	118	118	32	344	43	28	183	113	244	244	90	50
					16-Mar-87	7	-1									83	46	119	120	32		44	31	182	114	247	248	89	
					17-Mar-87	9	-2									87	46	123	121	32	371	48	28	189	115	254	249	90	54
					18-Mar-87	9	1									96	51	124	128	37	350	48	33	204	123	256	263	98	51
					19-Mar-87	13	0									87	48	126	118	32	357	55	32	189	118	258	244	90	52
					20-Mar-87	12	1									86	46	126	118	32	350	53	34	186	114	258	244	90	51
					21-Mar-87	12	2									92	47	124	124	29	316	53	35	197	117	256	256	85	46
					23-Mar-87											88	48	126	123	33	344			191	119	258	254	91	50
					24-Mar-87	17	1									88	50	119	118	38	344	62	33	190	122	246	245	101	50
					25-Mar-87	18	2									90	50	122	124	39	344	65	35	194	122	251	256	103	50
					26-Mar-87	17	8									92	53	124	126	46	350	62	46	198	127	255	259	114	51
					27-Mar-87	7	6									92	55	123	126	44	344	45	43	197	131	254	259	111	50
					28-Mar-87	9	7									90	49	119	123	38		48	45	194	121	246	253	101	
					30-Mar-87	17	9									87	51	124	126	38	357	63	48	189	124	256	258	101	52
					31-Mar-87	14	10									86	47	116	121	35	371	57	50	187	116	240	250	95	54
					01-Apr-87	0	-4									84	47	118	116	29		32	25	183	116	244	240	85	
					02-Apr-87	5	-1									88	49	117	118	34	357	41	31	190	120	243	245	94	52
					03-Apr-87	8	3									87	49	125	116	31	371	46	37	189	120	257	241	88	54
					04-Apr-87	19	3									88	46	118	116	29	371	66	38	190	115	245	240	85	54
					06-Apr-87	6	-2									86	47	117	115	27	364	43	29	186	116	243	239	80	53
					07-Apr-87	4	-1									87	49	126	116	33	364	40	30	189	120	258	241	91	53
					08-Apr-87	11	6									99	53	124	124	39	364	51	43	210	128	256	255	103	53
					09-Apr-87	18	7									91	48	121	118	34	357	64	45	195	119	249	244	94	52
					10-Apr-87	16	10									92	52	119	121	46	344	60	50	198	125	247	250	114	50
					11-Apr-87	19	4									91	52	124	117	43	357	67	40	195	125	256	243	110	52
					13-Apr-87	15	4									96	52	126	122	32	371	59	40	204	125	258	251	90	54
					14-Apr-87	11	2									90	51	118	117	39	357	52	35	194	124	244	243	103	52
					15-Apr-87	16	7									88	48	121	119	32	357	60	45	191	118	250	247	90	52
					16-Apr-87	6	4									94	48	126	124	29	344	43	40	201	118	259	256	85	50

LAB 9

Table G-IX
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	Injector Tip Soak Temperatures, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pres. kPa Max	Fuel Rail Pres. kPa Min	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pres. psi Max	Fuel Rail Pres. psi Min
(29)	9	F1	A	9F1-A																	289	261								42	38
(30)	9	F1	C	9F1-C		6	-11									93		87			302	261	42	12	199		189			44	38
(31)	9	F2	A	9F2-A		17	-3									93		86			289	261	62	27	200		186			42	38
(32)	9	F2	C	9F2-C		14	-11									97		83			289	261	57	13	207		182			42	38

LAB 10

Table G-X
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(33)	10	D	A	100-A	01-Dec-86	3	-3	94		103						103					357	37	26	218					52
					02-Dec-86	4	-4	97		105						105					357	39	25	221					52
					03-Dec-86	1	-2	90		101						101					371	34	29	214					54
					04-Dec-86	2	-2	82		93						93					385	35	28	199					56
					05-Dec-86	3	-4	93		101						101					357	37	24	214					52
					06-Dec-86	6	1	97		106						106					357	43	33	223					52
					08-Dec-86	8	4	97		107						107					357	46	40	224					52
					09-Dec-86	7	-7	95		104						104					357	45	20	220					52
(34)	10	D	C	100-C	09-Dec-86	7	-7	90		99						99					357	45	20	210					52
					10-Dec-86	-4	-9	90		98						98					357	25	15	208					52
					11-Dec-86	2	-7	90		98						98					357	35	20	208					52
					12-Dec-86	-5	-12	87		97						97					357	23	10	207					52
					13-Dec-86	-1	-12	93		102						102					350	30	10	215					51
					15-Dec-86	10	2	96		106						106					344	50	35	223					50
					16-Dec-86	7	4	97		107						107					344	45	40	224					50
					17-Dec-86	7	4	92		102						102					344	45	39	216					50
					18-Dec-86	3	2	93		103						103					344	38	35	218					50
					19-Dec-86	8	-1	97		107						107					337	46	30	225					49
					20-Dec-86	6	0	94		105						105					344	43	32	221					50
					22-Dec-86	4	-3	93		102						102					337	39	27	216					49
					23-Dec-86	3	1	94		105						105					344	38	34	221					50
					24-Dec-86	4	1	93		107						107					344	39	33	224					50
					29-Dec-86	4	1														344	39	33						50
					30-Dec-86	7	2														344	45	35						50
					31-Dec-86	3	2														344	37	35						50
					02-Jan-87	5	2														344	41	35						50
					03-Jan-87	6	1														344	43	33						50
					05-Jan-87	7	1														344	45	34						50
					06-Jan-87	10	2														344	50	35						50
					07-Jan-87	6	3														357	43	37						52
					[illegible]-Jan-87	3	1														364	37	34						53
					[illegible]-Jan-87	5	1														364	41	33						53
					10-Jan-87	8	1														344	46	33						50
					12-Jan-87	7	-1														344	45	30						50

LAB 11

Table G-XIa
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	Injector Tip Soak Temperatures, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pres. kPa Max	Fuel Rail Pres. kPa Min	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pres. psi Max	Fuel Rail Pres. psi Min
(35)	11	D	A	110-A1	16-Jan-87	14	8	91	107	107	86					107	112	116	111	22			58	46	225	234	240	231	72		
					19-Jan-87	20	6	87	104	104	82					104	109	112	109	26			68	42	219	228	234	228	78		
					20-Jan-87	17	5	92	109	109	87					109	114	117	114	24			62	41	228	237	243	237	75		
					21-Jan-87	14	4	89	104	104	81					104	107	116	111	24			58	39	219	225	240	231	75		
					22-Jan-87	13	9	92	107	107	87					107	111	117	111	24			56	48	225	231	243	231	75		
					23-Jan-87	13	7	86	102	102	82					102	109	112	107	22			56	45	216	228	234	225	72		
					26-Jan-87	16	10																60	50							
					27-Jan-87	14	8	101	104	96	84					104	109	114	109	21	378		58	46	219	228	237	228	69	55	
					28-Jan-87	14	8	106	107	102	87					107	114	116	112	26			58	47	225	237	240	234	78		
					29-Jan-87	14	10	104	106	[illegible]	86					106	112	114	111	24			58	50	222	234	237	231	75		
					30-Jan-87	14	7	104	106	99	86					106	112	114	112	26			57	44	222	234	237	234	78		
					02-Feb-87	13	6	102	104	99	86					104	111	112	109	26			56	42	219	231	234	228	78		
					03-Feb-87	16	11	102	104	101	89					104	109	112	109	26			60	51	219	228	234	228	78		
					04-Feb-87	18	7	99	101	106	84					106	109	114	109	26	378	323	64	44	222	228	237	228	78	55	47
					05-Feb-87	19	9	96	99	104	84					104	109	114	109	27			66	48	219	228	237	228	81		
					06-Feb-87	24	8	99	104	107	91					107	111	116	112	32			75	46	225	231	240	234	90		
					09-Feb-87	17	14	101	104	106	87					106	111	114	111	29			63	58	222	231	237	231	84		
					10-Feb-87	17	14	99	101	106	86					106	109	114	111	29			63	58	222	228	237	231	84		
					11-Feb-87	19	12	101	106	109	89					109	112	116	112	31			66	54	228	234	240	234	87		
					12-Feb-87	14	14	97	101	104	86					104	111	114	111	24			58	57	219	231	237	231	75		
					13-Feb-87	18	14	92	97	101	82					101	106	109	109	22		316	64	58	213	222	228	228	72		46
(36)	11	D	A	110-A2	13-May-87	25	15				96					96	116	117		32	378	344	77	59	204	240	243		90	55	50
					14-May-87	27	16				96					96	116	117		39			80	60	204	240	243		102		
					15-May-87	19	15				91					91	112	114		26			66	59	195	234	237		78		
					18-May-87	17	12				89					89	112	117		26			62	54	192	234	243		78		
					19-May-87	19	12				89					89	111	114		29			66	54	192	231	237		84		
					20-May-87	20	12				91					91	112	114		29			68	54	195	234	237		84		
					21-May-87	20	13				89					89	111	112		29			68	56	192	231	234		84		
					22-May-87	21	12	96	99		89					99	112	114		29	371	330	69	54	210	234	237		84	54	48
					26-May-87	21	12	97	99		91					99	112	116		29			69	53	210	234	240		84		
					27-May-87	21	13	97	101		89					101	112	114		32			70	56	213	234	237		90		
					28-May-87	22	13	96	[illegible]		87					99	112	114		34			72	55	210	234	237		93		
					29-May-87	19	13	97	[illegible]		86					99	111	114		29			67	56	210	231	237		84		
					01-Jun-87	33	13	101	[illegible]		94					104	116	117		37			92	56	219	240	243		99		
					02-Jun-87	37	16	99	[illegible]		92					104	114	116		41	378	337	98	61	219	237	240		105	55	49
					03-Jun-87	22	16	96	97		86					97	111	116		29			71	60	207	231	240		84		
					04-Jun-87	22	16	96	99		91					99	112	117		29			71	60	210	234	243		84		
					05-Jun-87	22	16	99	101		92					101	114	116		32			72	61	213	237	240		90		
					08-Jun-87	19	14	99	101		91					101	114	117		32			66	57	213	237	243		90		
					09-Jun-87	19	13	96	99		89					99	112	116		29			66	56	210	234	240		84		
					10-Jun-87	21	13	96	99		89					99	112	116		26			70	56	210	234	240		78		
					11-Jun-87	19	12	96	99		89					99	112	116		31	378	344	67	54	210	234	240		87	55	50
					12-Jun-87	26	13	96	99		91					99	111	111		36			78	55	210	231	231		96		
					15-Jun-87	23	16	94	97		87					97	111	114		27			73	60	207	231	237		80		
					16-Jun-87	23	13	94	99		87					99	112	116		32			74	56	210	234	240		90		
					17-Jun-87	22	13	96	99		89					99	112	114		32			72	56	210	234	237		90		
					18-Jun-87	21	13	94	103		87					103	111	116		27			70	56	217	231	240		81		

Lab 11, Run 36 continued on next page

LAB 11 (continued)

Table G-XIb
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pres. kPa Max	Min	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pres. psi Max	Min
(36)	11	D	A	11D-A2	19-Jun-87	20	13	92	97		87					97	111	116		29			68	55	207	231	240		84		
(continued)					22-Jun-87	29	14	101	104		92					104	116	117		37	378	350	84	57	219	240	243		99	55	51
					23-Jun-87	21	14	97	101		89					101	114	116		32			70	57	213	237	240		90		
					24-Jun-87	24	13	99	102		89					102	114	116		34			76	56	216	237	240		93		
					25-Jun-87	20	13	96	99		87					99	112	116		32			68	55	210	234	240		90		
					26-Jun-87	19	14	96	97		87					97	111	114		29			66	57	207	231	237		84		
					29-Jun-87	21	14	92	96		86					96	111	114		24			70	57	204	231	237		75		
					30-Jun-87	20	14	94	97		87					97	111	114		29	378	350	68	58	207	231	237		84	55	51
					01-Jul-87	21	14	94	96							96	111	112		26			69	58	204	231	234		78		
					02-Jul-87	23	13	96	97							97	112	114		32			74	56	207	234	237		90		
					06-Jul-87	23	14	99	102							102	112	114		34			74	58	216	234	237		93		
					07-Jul-87	31	15	101	104							104	116	117		41			87	59	219	240	243		105		
					08-Jul-87	24	15	96	99							99	112	114		32			75	59	210	234	237		90		
					09-Jul-87	21	16	91	96							96	109	114		27			70	60	204	228	237		81		
					10-Jul-87	19	14	92	96							96	112	114		26			67	57	204	234	237		78		
					13-Jul-87	22	15	94	97							97	112	114		24	378	357	71	59	207	234	237		75	55	52
(37)	11	D	A	11D-A3	26-Oct-87	16	5		102	102	92					102	117	121	112		371	330	60	41	216	243	249	234		54	48
					27-Oct-87	14	4	92	99	101	91					101	116	119	112				58	40	213	240	246	234			
					28-Oct-87	17	8		99	101	89					101	116	117	116				62	47	213	240	243	240			
					29-Oct-87	15	9																59	49							
					30-Oct-87	13	10	91	99		92					99	116	117	116		371	330	55	50	210	240	243	240		54	48
					02-Nov-87	23	15	86	92		87					92	111	114	114				73	59	198	231	237	237			
					03-Nov-87	30	14	91	97		92					97	114	119	116				86	58	207	237	246	240			
					04-Nov-87	39	16	91	97		89					97	112	114	114				102	60	207	234	237	237			
					05-Nov-87	40	19														371	344	104	66						54	50
					06-Nov-87	34	19																94	66							
					09-Nov-87	22	16																72	60							
					10-Nov-87	22	16	87	96	96	89					96	112	116	112				72	61	204	234	240	234			
					12-Nov-87	22	17	89	96	96	87					96	112	116	114				71	62	204	234	240	237			
					13-Nov-87	19	15	86	92	92	86					92	112	117	112				66	59	198	234	243	234			
					16-Nov-87	21	14																69	58							
					17-Nov-87	28	12	84	91	87	84					91	109	111	112	22			82	54	195	228	231	234	72		
					18-Nov-87	24	12														378	344	76	53						55	50
					19-Nov-87	20	13	87	94	91	86					94	111	114	112	29			68	55	201	231	237	234	84		
					20-Nov-87	18	11	87	94	89	84					94	112	116	114	22			64	52	201	234	240	237	72		
					23-Nov-87	21	16	91	97	99	87					99	116	119	116	29			69	60	210	240	246	240	85		
					24-Nov-87	24	14	89	96	94	86					96	112	114	114	22			76	57	204	234	237	237	71		
					25-Nov-87	27	14	91	96	91	86					96	112	116	114	26			81	57	204	234	240	237	78		
					30-Nov-87	22	13	86	87	86	82					87	112	116	112	16			72	56	189	234	240	234	60		
					01-Dec-87			89	94	91	84					94	112	116	111	21	399	371			201	234	240	231	69	58	54
					02-Dec-87			89	94	87	84					94	112	116	114	24					201	234	240	237	75		
					03-Dec-87			91	96	92	87					96	112	114	112	27					204	234	237	234	81		
					04-Dec-87			89	92	87	82					92	111	114	114	19					198	231	237	237	66		
					07-Dec-87			91	94	96	84					96	112	114	114	26					204	234	237	237	78		
					08-Dec-87			92	96	96	86					96	112	116	116	22					204	234	240	240	72		
					09-Dec-87			90	94	82	81					94	112	114		21					201	234	237		69		
					10-Dec-87																357	330								52	48

Lab 11 continued on next page

LAB 11 (continued)

Table G-XIc
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run	Lab	Car	Fuel	Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pres. kPa Max	Fuel Rail Pres. kPa Min	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pres. psi Max	Fuel Rail Pres. psi Min
(38)	11	D	C	11D-C	26-Mar-87	24	9	94	103	103	97					103	116	118	114	33	371	344	76	49	218	240	245	238	91	54	50
					27-Mar-87	24	9	91	99	95	91					99	112	118	114	33			76	48	210	234	245	238	91		
					30-Mar-87	26	9																78	49							
					31-Mar-87	26	10	92	101	109	96					109	114	117	127	31			78	50	228	238	243	260	88		
					01-Apr-87	24	9																76	49							
					02-Apr-37	20	16	91	99	109	92					109	114	117	113	27			68	60	228	238	243	236	81		
					03-Apr-87	20	12	91	97	107	92					107	112	116	114	29			68	54	225	234	240	238	85		
					06-Apr-87	22	9																71	49							
					07-Apr-87	23	11														378	337	74	52						55	49
					08-Apr-87	24	12	109		107	111					111	114	117	116	34			76	54	231	237	243	240	93		
					09-Apr-87	24	12																76	53							
					10-Apr-87	23	13																74	55							
					13-Apr-87	27	9	111		109	101					111	116	117	117	32			80	49	231	240	243	243	90		
					14-Apr-87	24	11	111		108	99					111	114	117	117	32			75	52	231	237	243	243	90		
					15-Apr-87	31	10														378	337	87	50						55	49
					16-Apr-87	27	13																81	55							
					17-Apr-87	21	12																70	53							
					20-Apr-87	28	10	92		106	102					106	116	118	117	34			83	50	222	240	245	243	93		
					21-Apr-87	32	12																90	54							
					22-Apr-87	27	13	91		102	99					102	112	117	114	32			80	55	216	234	243	237	90		
					23-Apr-87	19	12	89		99	92					99	112	116	112	26			66	54	210	234	240	234	78		
					24-Apr-87	21	12	91		104	96					104	114	117	117	27	371	330	70	54	219	237	243	243	81	54	48
					27-Apr-87	21	12	92		102	96					102	114	117		34			69	54	216	237	243		93		
					28-Apr-87	20	12	91		101	96					101	114	116		31			68	54	213	237	240		87		
					29-Apr-87	18	12	89		101	92					101	114	116		26			64	53	213	237	240		78		
					30-Apr-87	18	12	86		99	91					99	112	116		26			65	53	210	234	240		78		
					01-May-87	20	14	91		101	94					101	112	116		32			68	57	213	234	240		90		
					04-May-87	27	13	94		105	96					105	114	117		37			80	56	221	237	243		99		
					05-May-87	36	14	96		109						109	117	117		42	378	337	97	58	228	243	243		108	55	49
					06-May-87	33	16	96		107						107	117	118		37			91	61	225	243	244		99		
					07-May-87	34	17	93		107						107	114	116		41			94	62	225	237	240		105		
					08-May-87	21	15	91		104						104	113	117		32			70	59	219	236	243		90		
					11-May-87	19	13	91		105						105	116	117		32			67	56	221	240	243		90		
					12-May-87	22	13	92		106						106	116	117		34	378	344	72	56	222	240	243		93	55	50

LAB 12

Table G-XII
CRC PORT FUEL INJECTOR DEPOSIT ROUND ROBIN PROGRAM
TEMPERATURE DATA

Run Lab Car Fuel Code	Date	Ambient Max C	Ambient Min C	INJECTOR TIP SOAK TEMPERATURES, C 1	2	3	4	5	6	7	8	Max	Inlet Air C	Coolant C	Oil C	Fuel Tank C	Fuel Rail Pressure kPa	Ambient Max F	Ambient Min F	Inj Max F	Inlet Air F	Coolant F	Oil F	Fuel Tank F	Fuel Rail Pressure psi
(39) 12 D A 12D-A	06-Feb-87	8	-3															47	27						
	20-Feb-87	6	-3															42	26						
Excluded	03-Mar-87	8	0															46	32						
from	09-Mar-87	16	-4															61	25						
Analysis	16-Mar-87	8	-1															47	31						
	24-Mar-87	21	3															70	38						
(40) 12 D C 12D-C	24-Mar-87	21	3															70	38						
	30-Mar-87	17	8															62	46						
Excluded	03-Apr-87	14	6															58	43						
from	09-Apr-87	17	8															62	46						
Analysis	15-Apr-87	16	7															60	45						
	21-Apr-87	26	13															79	56						
	24-Apr-87	17	7															62	45						
(41) 12 S A 12S-A	07-Feb-87	11	-1															51	31						
	23-Feb-87	6	0															43	32						
Excluded	27-Feb-87	7	-2															44	29						
from	05-Mar-87	6	-3															43	27						
Analysis	10-Mar-87	-1	-9															30	16						
	13-Mar-87	6	0															42	32						
	20-Mar-87	9	1															48	34						
(42) 12 S C 12S-C	26-Mar-87	19	8															67	47						
	03-Apr-87	14	6															58	43						
Excluded	09-Apr-87	17	8															62	46						
from	15-Apr-87	16	7															60	45						
Analysis	30-Apr-87	16	9															60	49						
	05-May-87	11	7															51	44						
	07-May-87	27	8															80	46						

APPENDIX H

STATISTICAL ANALYSIS
OF
FUEL INJECTOR FLOW DATA

APPENDIX H

STATISTICAL ANALYSIS OF CRC PORT FUEL INJECTOR PLUGGING DATA

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STATISTICS PLUS

26 February 1988

SUMMARY

The fuel injector plugging data were analyzed with two different models:

1. Exponential drop of percent of original flow to a lower limit (which could be zero flow) with miles on test.
2. A simple linear fit of percent flow reduction to miles on test, through the origin (without an intercept).

The parameters of these two models were then analyzed for fuel and engine type effects and subjected to an analysis of precision for repeated tests in a given car and for car-to-car variability. The exponential model is comple ely equivalent to looking at percent flow reduction starting at zero at zero test miles and rising at an exponentially decreasing rate to a fitted upper limit of percent flow reduction. The analyses for fuel and engine type effects were finally done in terms of the fitted flow reductions at 3K, 6K, and 10K miles for the exponential model, and slope for the simpler linear model.

Statistical analyses of all four measures of fuel and engine effects showed the same patterns, with all effects significant at at least the 95% level:

	Low > > > > > > > > > High Plugging		
Fuel	B	C	A
Engine	L	GD	F

Engine types G and D are not significantly different from each other. A detailed tabulation of these results is given in Table H-I, which shows the fitted relationships, the significance levels for the effects, and the fitted mean values for each fuel and engine type.

The test variability, both between repeated tests in the same vehicle and between different cars of the same engine type, is very high. For example, the difference of two single run slopes from a single car has to exceed 1.17 times the average of the two before the pair can be considered suspect. Similarly, the difference of the slopes from two different cars with the same engine type has to exceed 1.36 times the average before the results can be considered suspect. The precision relations are shown in Figures H-1, H-2, and H-3, showing the 95% confidence limits for the difference between two results as a function of their average. Thus, in standard ASTM D02 terminology, the difference between two results should not exceed the charted values more than one time in twenty, in the normal course of running the test as specified.

ANALYSIS DETAILS

The exponential model fits the data quite well, picking up readily those runs which showed a definite nonlinear pattern. For the runs where the plugging rate was high and there was no decided nonlinear pattern, the fitted lower limit on flow rate was close to zero.

Statistically, there is not much difference between the several measures of injector plugging performance. All four show highly significant differences between the fuels and engine types. If anything, the simple linear fitting shows slightly greater significance, but this is due mainly, I believe, to the fact that the lower plugging fuels and engines show a more decided tailing-off of plugging with test miles while the linear model tends to ignore the data close to the origin and fits more closely the high mileage points. This effect, sketched in Figure H-4, increases slightly the magnitude of the differences between the "good" and the "bad" fuels and engines, at least at 3000 miles.

The results of the fuel and engine type effects analyses are summarized in Table H-I, which shows I: the fitted relationships, II: the null hypothesis probabilities (small values indicate highly significant effects), and III: the least squares fitted mean values for each fuel and engine type. Using the 3K miles results as an example, let's look at what each section of Table H-I means.

I. FITTED MODEL COEFFICIENTS:

The numbers given here represent the coefficients in an equation for estimating the flow reduction at 3K miles ($\%\delta$ = percentage plugged, $100-\%\delta$ = percentage clean or not plugged):

Thus $\ln(\%\delta/(100-\%\delta))$ = -4.046
+0.774 for Fuel A, or
-1.301 for Fuel B, or
+0.0 for Fuel C

+1.292 for Engine D, or
+2.064 for Engine F, or
+1.003 for Engine G, or
+0.0 for Engine L.

We see from this that the intercept is the estimated value of $\ln(\%\delta/(100-\%\delta))$ for Fuel C and Engine L. Fuel C and Engine L were chosen as the "reference" fuel and engine simply because C and L are farther down the alphabet than the other codes. To use the equation for estimating a value for Fuel B in Engine F, we take -4.046 -1.301 + 2.064 = -3.283. Working backwards through the log function, we find

$$\%\delta = 100/(1 + \exp(-(-3.283))) = 3.62\%.$$

II. TAIL PROBABILITIES

These values estimate the probability that we would obtain a value for a model coefficient at least as big as was fitted when the true value of the coefficient is really zero. All fuel effects are relative to Fuel C and all engine effects are relative to engine type L. As the probabilities are all low, we have high confidence that the observed fuel and engine effects are real.

III. FITTED LEAST SQUARE MEANS:

These are estimates of what the averages for each fuel and engine type would have been if the experimental layout had been perfectly balanced, with all cars having been run on all fuels.

So, for Engine D, $-4.046 + (0.774-1.301+0)/3 + 1.292$
$= -4.222 + 1.292 = -2.930$

$$\%\delta = 100/(1 + \exp(2.930)) = 5.07.$$

What was done here was to take the intercept, add the average of the three fuel effects, then add the specific engine effect and then "defunctionalize."

For the Fuel B mean, -4.046 + average of the 4 engine effects + the B coefficient, or

$$-4.046 + (1.292+2.064+1.003+0)/4 - 1.301$$
$$-4.046 + 1.0898 - 1.301 = -4.257$$

$$\%\delta = 100/(1 + \exp(4.257)) = 1.40.$$

As expected, Fuel A shows greater plugging tendencies than Fuel C, while Fuel B is better than C. This implies that Fuel A is also significantly worse than Fuel C. The situation is somewhat different for engine types: each of the types D, F, and G has significantly greater plugging tendencies than Engine Type L, and F is significantly worse than either D or G, but D and G are not significantly different from each other.

The differences between repeated runs in the same car were analyzed to estimate a Repeatability value, while the differences among cars of a given engine type on each of the fuels were used to estimate Reproducibility (here actually car-to-car variability). The resultant precision estimates are not very well defined since they are based on relatively few degrees of freedom (only nine for Repeatability, and 19 for car-to-car variation).

The 3K and 6K Car-to-Car (same engine type) variations were not distinguishable and so were pooled for final presentation. The repeat (same car) variation was substantially the same for all three mileages and was therefore pooled. The individual relationships are shown in Figure H-5, with the pooled 3K/6K being shown in Figure H-1, and the 10K precision in Figure H-2. The flow reduction functions used for the precision analysis are the same as shown in Table H-I, namely: ln { %δ / (100 - %δ)} for the 3K, 6K and 10K results and ln { slope } for the simple linear model. The standard deviations for the precision functions are as follows:

	Standard Deviations			
	within car		car-to-car (same engine type)	
Flow Reduction @		pooled		pooled
3K miles	0.504	0.497	0.667	0.656
6K miles	0.475		0.644	
10K miles	0.511		0.753	
Linear Slope	0.472		0.588	

The transformation used for % plugging at 3K, 6K, and 10K miles results in a complicated precision expression, the results of which are shown in Figures H-1 and H-2 using the pooled values from the table above. Figure H-5 shows all the individual precisions simply to indicate how close are the several values that were pooled.

The logarithmic function for slope allows the slope precisions to be expressed simply as multiples of the average of the two measured slopes, to wit:

Car-to-car (Reproducibility) = 1.36*Mean Slope
Same car (Repeatability) = 1.17*Mean Slope

These relationships are graphed in Figure H-3.

A detailed examination for statistical outliers was made for all fuel-engine type combinations in which five or more tests were run. No results could be declared outliers at the 99% significance level. And those few that were borderline at the 95% level were not the tests that were considered suspect by the originating labs. Thus no deletions have been made from the data for any of the analyses. The car-to-car variability also includes any lab-to-lab effects. There simply were not enough cars run at each of the labs to attempt to isolate any separate lab effects.

An analysis for the effects of various external conditions (soak temperatures, whether tests were run indoors or out, etc., was not made because it was considered highly unlikely that anything useful would come from the effort. The basic reasoning here is that it is difficult enough to find minor effects in a well designed test program, but with the temperatures, modes of operation, etc. coming about in a totally unplanned way, it would be impossible to trust any of the statistical analysis results. No printed significant or insignificant results could be believed.

ACKNOWLEDGEMENTS

I would like to thank Mr. Brian Y. Taniguchi for his assistance in providing interpretation of the data and the Chevron Research Company for the use of the Chevron computing system in making the statistical analyses.

TABLE H-I

FUEL AND ENGINE TYPE EFFECTS: SUMMARY

I. FITTED MODEL COEFFICIENTS

		Analyzing Flow Reductions @ 3K Miles	6K Miles	10K Miles	Linear Slope
Intercept		-4.046	-3.718	-3.616	-0.755
Fuel:	A	+0.774	+0.908	+1.048	+0.774
	B	-1.301	-1.518	-1.676	-1.402
	C	0	0	0	0
Eng.:	D	+1.292	+1.481	+1.708	+1.337
	F	+2.064	+2.360	+2.721	+2.053
	G	+1.003	+1.177	+1.362	+1.081
	L	0	0	0	0

II. TAIL PROBABILITIES

		Analyzing Flow Reductions @ 3K Miles	6K Miles	10K Miles	Linear Slope
Fuel:	A	.0017	.0005	.0004	.0008
	B	.0025	.0008	.0011	.0006
	C	.	.	.	.
Eng.:	D	.0090	.0043	.0039	.0038
	F	.0002	.0001	.0001	.0001
	G	.0482	.0265	.0243	.0224
	L	.	.	.	.

III. FITTED LEAST SQUARE MEAN VALUES

		Analyzing Flow Reductions @ 3K Miles	6K Miles	10K Miles	Linear Slope
Fuel:	A	10.14	17.44	24.60	3.11
	B	1.40	1.83	2.10	0.35
	C	4.94	7.85	10.26	1.44
Eng.:	D	5.07	8.02	10.74	1.45
	F	10.36	17.36	24.90	2.97
	G	3.85	6.05	7.85	1.12
	L	1.45	1.94	2.14	0.38

Flow Reductions analyzed as ln { %δ / (100 - %δ) }
Slope analyzed as ln { slope }

FIGURE H-1

PRECISION POOLED
% FLOW REDUCTION AT 3K AND 6K MILES

CRC-PFI Study - Exponential Model
95% Confidence Limits for Difference of Two Results

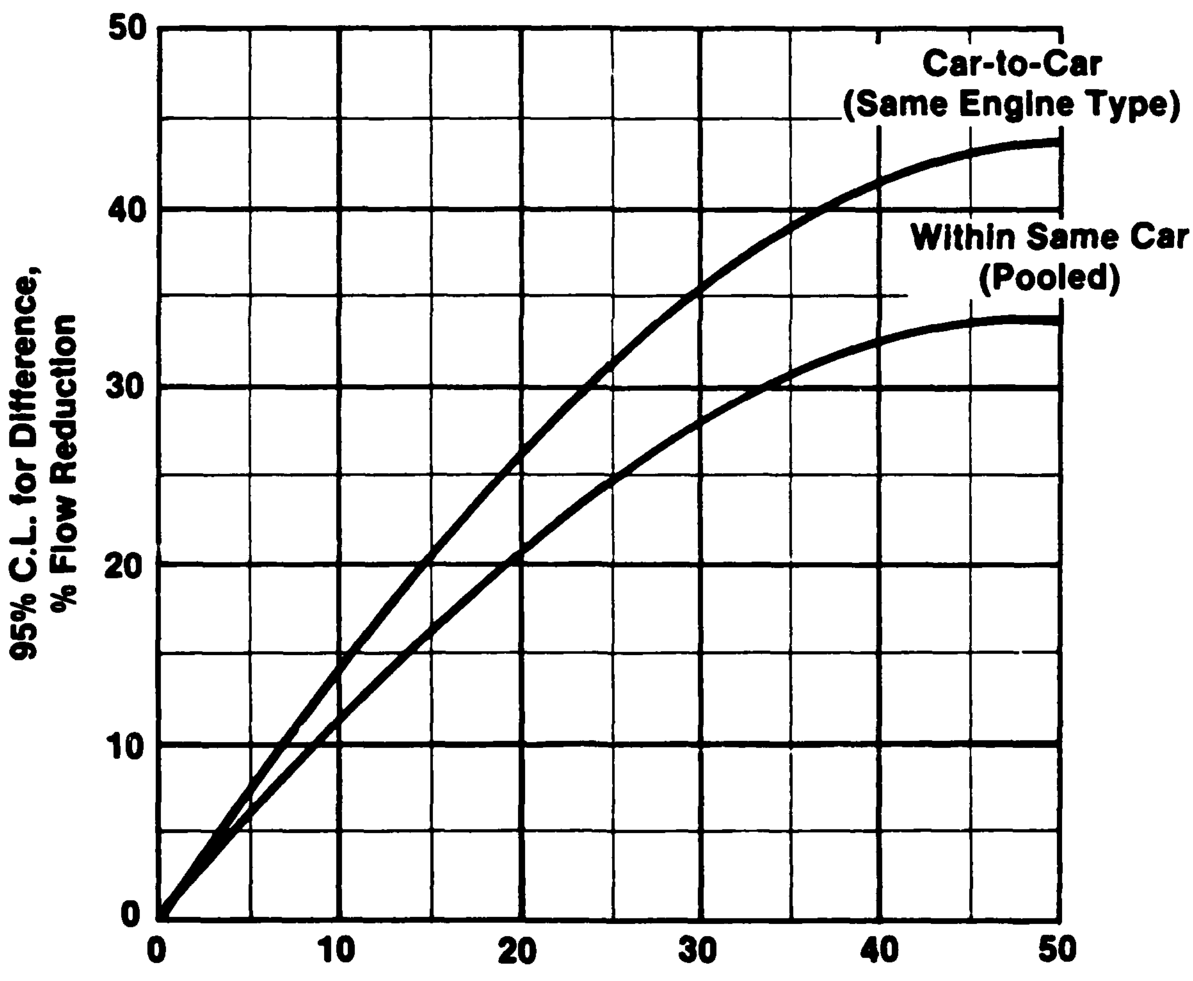

FIGURE H-2

PRECISION % FLOW REDUCTION AT 10K MILES

CRC-PFI Study - Exponential Model
95% Confidence Limits for Difference of Two Results

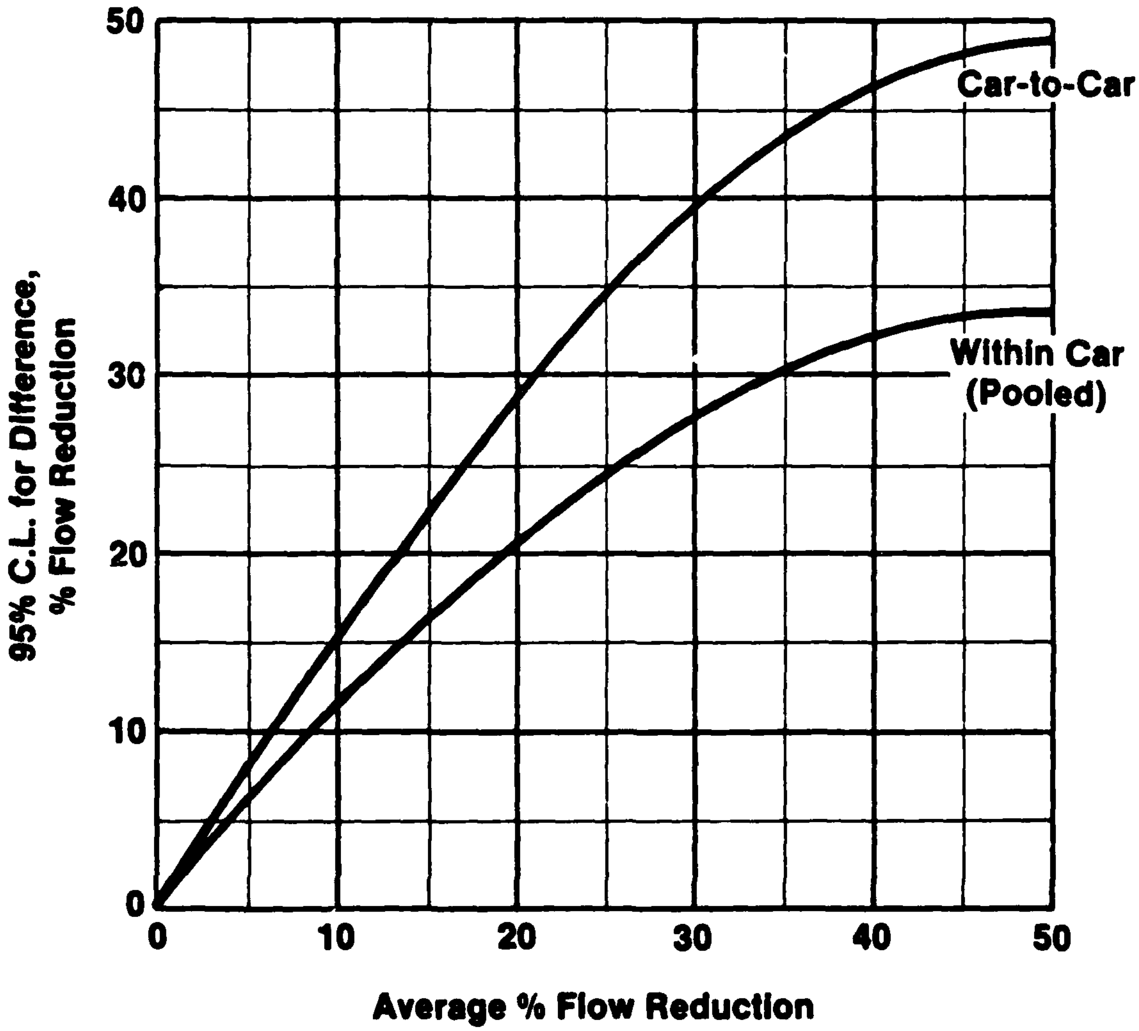

FIGURE H-3

PRECISION LINEAR SLOPE
% FLOW REDUCTION/1000 MILES

CRC-PFI Study - Linear Model
95% Confidence Limits for Difference of Two Results

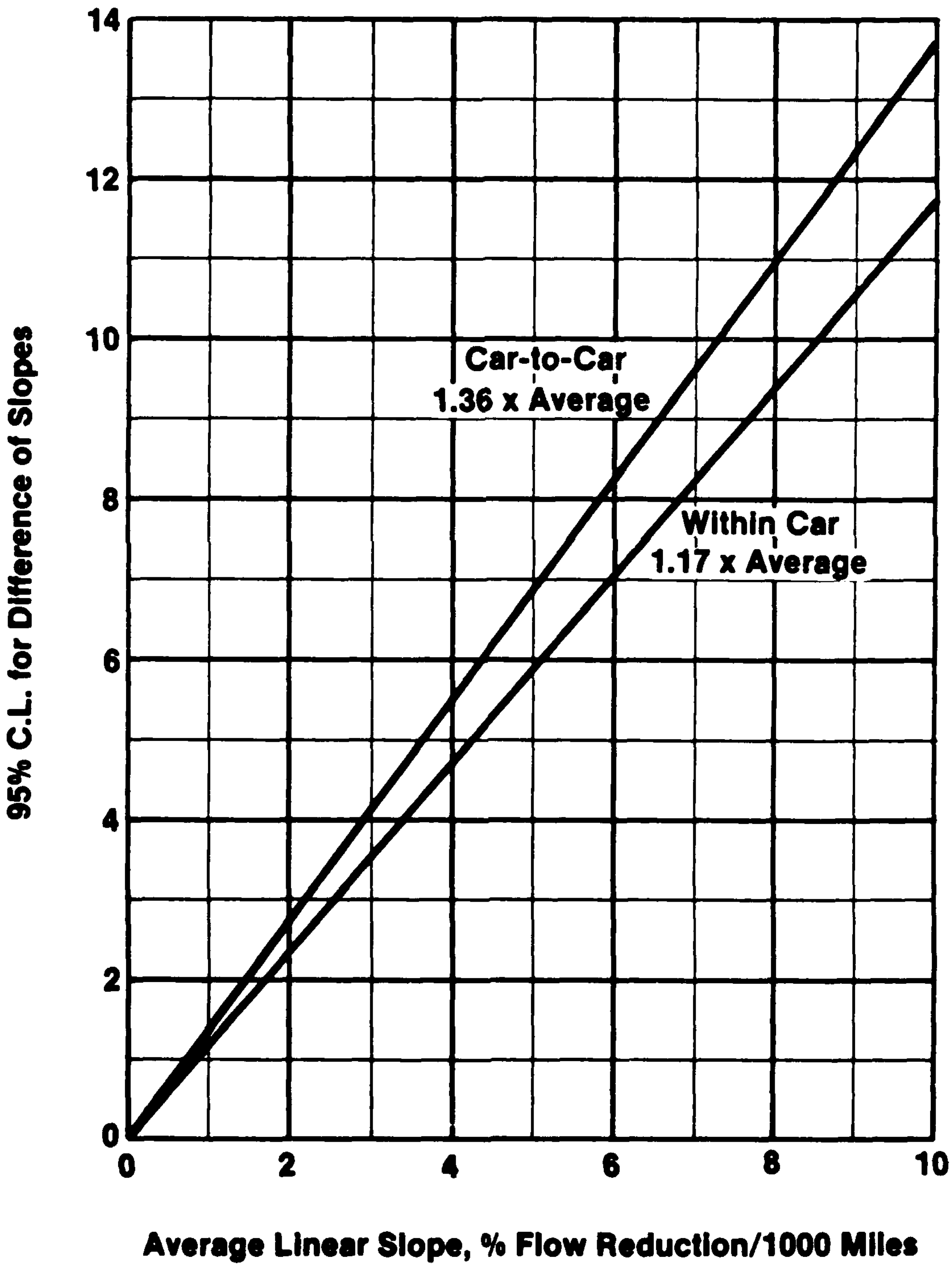

FIGURE H-4

SCHEMATIC PICTURE OF DIFFERENCES IN FITTING EXPONENTIAL MODEL VERSUS SIMPLE LINEAR REGRESSION

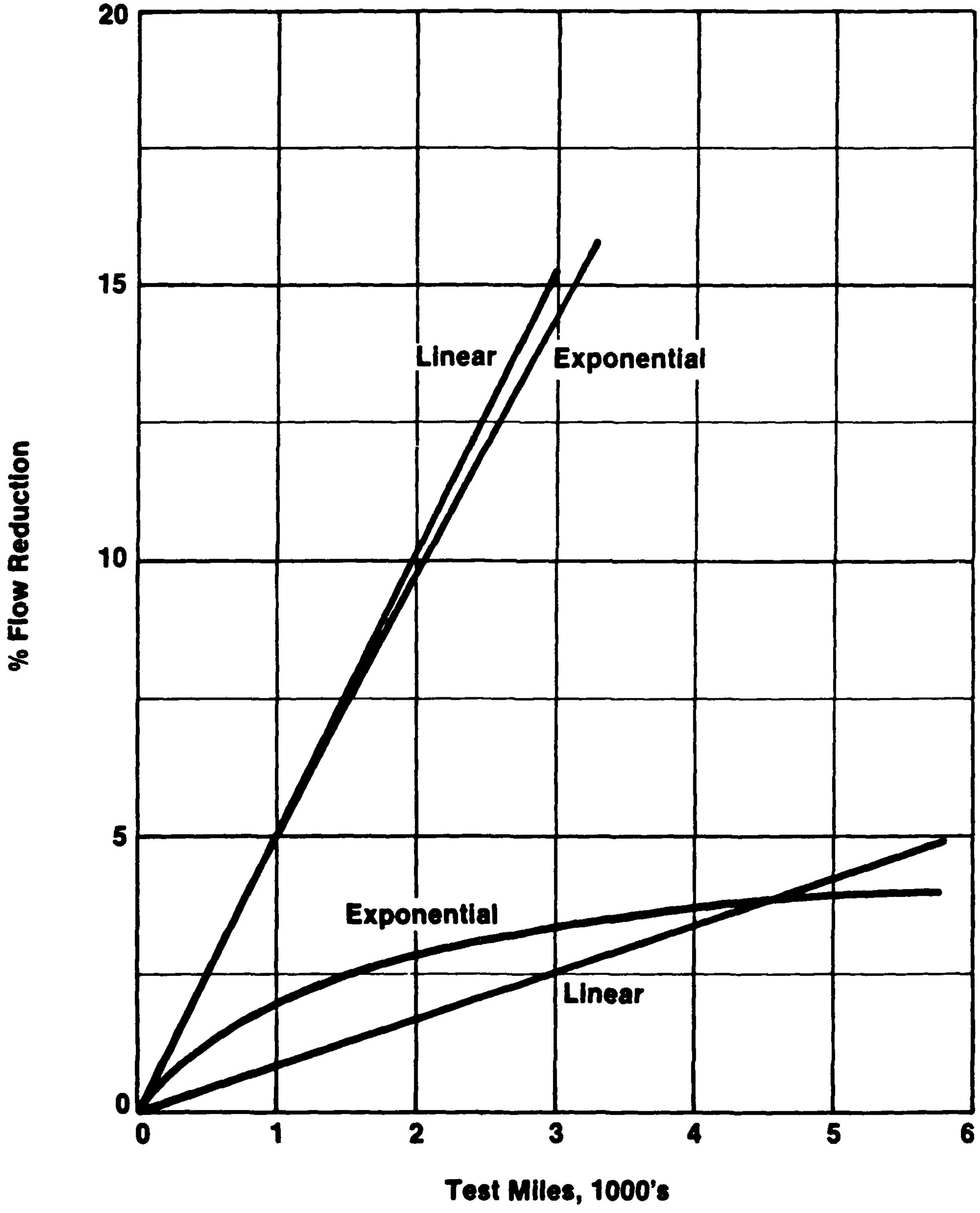

FIGURE H-5

PRECISION % FLOW REDUCTION AT 3K, 6K, 10K MILES
EXPONENTIAL MODEL

95% Confidence Limits for Difference of Two Results